The Status of Hospital Maintenance Management: Result from Survey

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Abstract

Regulation of the minister of Health of the Republic of Indonesia define hospital as a health institution that organizes individual health services that provide inpatient, outpatient and emergency services. The performance function of its facility and equipment are critical due to the operation time of hospital is 24 hours a day. In term of maintenance management, the hospital with highly effective maintenance are could be considered as a good quality hospital. By establishing the key factors influencing the success of maintenance management, this paper will present the status of hospital care through a survey of 30 hospitals. Analysis of significant factors associated with high-effectiveness maintenance management was performed using statistical analysis (2 sample t-test). An analysis was also carried out on the correlation between the maintenance success factors. Radar diagram is made to describe the status of maintenance in the hospital which is divided into four categories, namely innocence, understanding, obedient and excellence. The chart shows that all hospitals have implemented good policy deployment and organization. This paper also presents opportunities for further research that can be undertaken to improve maintenance management in hospitals.

Keywords
Maintenance, Survey, Hospital, Statistical Analysis and Correlation Analysis.

1. Introduction
Regulation of the minister of Health of the Republic of Indonesia define hospital as a health institution that organizes individual health services that provide inpatient, outpatient and emergency services. General Hospital is a hospital that provides health services in all fields and types of diseases. Special Hospital is a hospital that provides primary services in one field or type of disease based on scientific discipline, age group, organ, type of disease or other specificities. There are some of stakeholder in hospital such as patients, public or visitor, administrative and medical staff (Rani et al. 2014). Due to the operation time of hospital is 24 hours a day (Shohet 2003), making the performance function of its facility and equipment are critical. Maintenance management are play an important role to maintain the hospital's facility and equipment are work properly to still be able to serve all the stakeholder needs. Inefficient resource allocation, inadequate coordination and deployment of maintenance program, and ineffective workflow monitoring is main issues that contribute to deferred maintenance in hospital (Alzaben 2015). Maintenance strategy that applied in hospital is significantly impacted to the maintenance budget (Yousefli et al. 2017) as well as the effectiveness of maintenance execution. In term of maintenance management, the hospital with highly effective maintenance are could be considered as a good quality hospital.

1.1 Objectives
Since the hospital is an essential public facility, it is deservedly that hospital maintain its facility and equipment to be able serve well all its stakeholder. The objective of this research is to assess the maintenance policy deployment and organization, human resource management, Financial aspect, task planning and scheduling, contracting out maintenance, spare part management, maintenance approach, and information management and computerized maintenance management systems as variables to determine the effectivity of maintenance management in hospital in Indonesia.

2. Literature Review

The complexity and criticality of healthcare services highlight the importance of maintenance management function in healthcare facilities (Yousefli et al. 2017). According to the literature review, several issues which affect facility maintenance management in hospital buildings were identified, including budget limitations, high expenditures, criticality of services, customer satisfaction, complexity of information and decision-making. To address some of these issues, research has emerged in maintenance cost efficiency, maintenance resource allocation, maintenance performance measurement, and maintenance strategic planning (Yousefli et al. 2017). The prioritization and scheduling of maintenance activities in hospitals should be systematically linked through an integrated model that considers the criticality of services, the age of facilities, and the peak and base demands for this service. In addition, the healthcare sector, due to its criticality of services, should consider adopting availability-based maintenance strategies, currently in practice in power industry, to ensure service continuity while avoiding over maintenance and maintenance budget allocation inefficiencies (Yousefli et al 2017).

Cholasuke (2004) said the importance of the facility maintenance management in the manufacturing environment has increased rapidly as many organisations aim to become world class. For many organisations it is important to respond to the global competitive pressure by seeking to increase their productivity, maximizing the overall equipment effectiveness and pursing an effective and efficient maintenance program. Effective maintenance management is a growing concern of the UK manufacturing industry. Research has shown that the number of companies using proactive maintenance approach in the UK manufacturing business has increased significantly over the last few years.
Maintenance in the manufacturing sector assumes a critical role as a support activity. An acceptable level of performance of the industry is simply unattainable without an effective maintenance management support. The analysis shows that the "maintenance approach" and "continuous improvement" significantly contribute to an effective maintenance management program.

Gebauer et al. (2008) A different understanding of the role of maintenance activities requires a cultural change in Chinese manufacturing firms. The management must create a culture with the business so that all different functional units understand the maintenance management and the implication of their actions on maintenance management. Management must set up a system for continuous improvement at all levels in the maintenance unit. Maintenance managers and engineers must be trained more intensively to establish an appropriate skill base. Furthermore, continuous improvements in equipment reliability through maintenance management require more cooperation with suppliers of manufacturing equipment and third-party maintenance service providers. Instead of establishing their own maintenance skills, Chinese manufacturing firms can benefit from outsourcing maintenance activities toward such firms. Partnership with suppliers of machines and equipment can decrease operating costs by increasing reliability and integrity. This leads to an improved business performance.

Over the last few years, the Reliability Engineering and Risk Management Group (RERMG) at the University of Queensland has developed an approach called the strategic maintenance management (SMM) approach. The SMM approach developed by the RERMG at the University of Queensland involves linking the technical, operational and commercial issues in an integrated framework (Murthy 2002). The key features of the approach are: understanding of the science of degradation; need for proper data collection and analysis; use of mathematical models for evaluating alternate maintenance strategies and for selecting the optimal maintenance strategy; and continuous improvement in business performance.

Tse (2002) conducted a study related to automatic maintenance scheduler. The AMS (Automatic Maintenance Scheduler) provides schedules for maintenance activities according to the operational conditions of the machines that are monitored. Such a comprehensive maintenance scheme minimizes the chances of fatal machine breakdowns and the loss of production. Inventory overstocking can also be avoided by ordering spare parts just in time. Moreover, the planning of maintenance, including the allocation of labor and materials, can be optimized. Large-scale tests that were performed in a power generation plant reduced the breakdown of equipment and the interruption of production and saved a significant amount of resources that would otherwise have been wasted by unnecessary maintenance services.

Maintenance measurement: a comparative study
Industry accepted that maintenance is a key function in sustaining long-term profitability for organizations (Nurcahyo et al. 2018). Tsang et al. (1999) mentioned that maintenance measurement is needed to give the maintenance manager quantitative information on the extent to which maintenance goals can be reached and what action is to be taken to improve the operations to meet the goals.

Policy deployment and organization
How efficiently the maintenance function operates also depends highly on the maintenance of organizational structure (Ingalls 2000). The hierarchy of communications and maintenance resource allocation with the right capabilities in the right maintenance areas is essential (Kelly 1997). The complexity and criticality of healthcare services highlight the importance of maintenance management function in healthcare facilities (Yousefli et al. 2017).
The continuous involvement of the management is rudimentary to provide the guidance and direction to the maintenance function (Cholasuke 2004). The management must create a culture with the business so that all different functional units understand the maintenance management and the implication of their actions on maintenance management (Gebauer et al. 2008).
An appropriate maintenance activity is required for business class seats with consistency and correct method with precise time estimates in predicting and maintaining the performance of electrical and mechanical components present in business class seats (Nurcahyo et al. 2017). MRT operation and maintenance cost components need to be modeled based on regulations and conditions in the respective country and region to obtain valid calculations (Nurcahyo et al. 2019).

Human resource management
The important factors related to the successful maintenance resource planning include: skill and training, job motivation and sufficient maintenance human resources (Cholasuke 2004). Management has to set up a system for continuous improvement at all levels in the maintenance unit. Maintenance managers and engineers must be trained more intensively to establish an appropriate skill base (Gebauer et al. 2008).
To optimize maintenance performance, several aspects of skill and competency maintenance team needed to be concerned in maintenance management. Training is an important element in increasing skills, competency and creating high work performance culture (Nurcahyo et al. 2018). To ensure the maintenance performance result by an effective training, it becomes important to carefully investigated the different training success factor and maintenance performance parameter (Nurcahyo et al. 2018).

Financial Aspect
The financial control of maintenance includes the control over the maintenance budget, the contractor cost monitoring and, overall labor and material cost control (Ingalls 2000). The annual maintenance costs as a fraction of the total operating budget varies across industry types. Typical maintenance costs are between 20 and 30 per cent of the total operating budget (Gebauer et al. 2008). Even though the assets and the profits of the companies were substantial, the budgets that were committed to maintenance were not proportionate to the overall expenditure, with the exception of the transportation sector. Hong Kong companies, particularly those that are involved building services, should invest more in maintenance and employ advanced maintenance practices (Tse 2002).
The spare parts component management strategy is one of the aircraft's operating plans and plays an important role in efficiency efforts to lower aircraft operating costs (Nurcahyo et al. 2017). The cost model calculation determined that Jakarta MRT operation and maintenance costs total USD 8.44 million per kilometer per year. This result was compared to other countries' MRT operations (Nurcahyo et al. 2019).

Task planning and scheduling
Preventive maintenance and production scheduling are related to each other due to well scheduled preventive maintenance will reduce the likelihood of machine down time that can interfere production (Nurcahyo et al. 2016).
Maintenance plans and schedules help in scheduling maintenance work and allocating the resource for each work (Cholasuke 2004). The prioritization and scheduling of maintenance activities in hospitals should be systematically linked through an integrated model that considers the criticality of services, the age of facilities, and the peak and base demands for these services (Yousefli et al. 2017).

Contracting out maintenance
An ineffective sub-contractor can lead to high maintenance cost and low maintenance performance (Cholasuke 2004). To include outsourcing, several authors introduce a strategic maintenance approach (Murthy et al. 2002). The strategic

maintenance approach interprets maintenance either as a vital core business activity crucial for business survival and success or a non-core activity that should be outsourced to external service providers (Gebauer 2008) Instead of establishing their own maintenance skills, Chinese manufacturing firms can benefit from outsourcing maintenance activities toward such firms. Partnership with suppliers of machines and equipment can decrease operating costs by increasing reliability and integrity (Gebauer et al. 2008).

Spare part management

The management of spare parts availability plays an important role in a wide range of industries, such as the aviation industry, freight services, and manufacturing industries (Nurcahyo et al. 2017).

Maintenance spare part inventory can lead high maintenance cost (Kirby 2000). The healthcare sector, due to its criticality of services, should consider adopting availability-based maintenance strategies, currently in practice in power industry, to ensure service continuity while avoiding over maintenance and maintenance budget allocation inefficiencies (Yousefli et al. 2017). Continuous improvements in equipment reliability through maintenance management require more cooperation with suppliers of manufacturing equipment and third party maintenance service providers (Gebauer et al. 2008). Inventory overstocking can also be avoided by ordering spare parts just in time (Tse 2002).

Maintenance approach

Preventive maintenance model aims to optimize the periodic replacement of significant parts while production scheduling model aims to meet the demand for distributors (Nurcahyo et al. 2016).

Maintenance technique used can very highly affect maintenance performance (Cholasuke 2004). Companies can either use condition-based preventive maintenance or reliability-centered maintenance to implement predictive maintenance practices (Tse 2002). Research has shown that the number of companies using proactive maintenance approach in the UK manufacturing business has increased significantly over the last few years (Cholasuke 2004).

Chinese manufacturing companies can improve business performance only by changing toward predictive and total productive maintenance in combination with the outsourcing of maintenance activities (Gebauer et al. 2008). The results of a recently conducted survey indicate that equipment failure-driven and time-based maintenance are most commonly used in Hong Kong. Only a few companies use condition-based preventive maintenance (Tse 2002).

With Markov simulation, predictive maintenance recommendation of each component will be obtained for which the component can reach its maximum lifetime and from the vendor recommendation it will be translated into periodic maintenance work for the business class seats that is preventive maintenance (Nurcahyo et al. 2017).

Information management and computerized maintenance management systems (CMMs)

Mathematical models used for preventive maintenance is a simple optimization model, while the mathematical model used for production scheduling is an Integer Linear Programming (Nurcahyo et al. 2016).

It is about the management of all maintenance related data, which includes collecting, analyzing and transforming data into information to provide the report and feedback to the appropriate function (Both mentioned in Wilson 1999).

The key features of the strategic maintenance management (SMM) approach are: understanding of the science of degradation; need for proper data collection and analysis; use of mathematical models for evaluating alternate maintenance strategies and for selecting the optimal maintenance strategy; and continuous improvement in business performance (Murthy 2002). From the calculation of the evaluation that expert choice software can be used as a tool in the calculation of multi criteria AHP on the management of aircraft spare parts inventory (Nurcahyo et al. 2017).

3. Methods

We do these following steps for our research.

Literature review

To get better understanding of the topics, we read some journals and articles related to preventive maintenance, variables on maintenance management, maintenance survey, and so on. The purpose of doing these were: to understand the concept of preventive maintenance and get the depiction how maintenance programs being applied in daily activity at real places. Thus, we can formalize the framework of our research.

Survey questionnaire making

After getting clear view of preventive maintenance and affecting factors of preventive maintenance, we frame the questionnaire based on the target variables we would like to know. These are at least eight big factors of affecting variables we highlighted: policy deployment and organization, human resource management, financial aspect, task

planning and scheduling, contracting out maintenance, spare part management, maintenance approach, and information management and computerized maintenance management systems (CMMS). Each of the factor contained couples of key questions that can elucidate the factor. We decided to focus our research on hospital maintenance management.

Data collection
We served at least 27 questions from 8 big factors on Google form and distributed the link to our colleagues. The panelist must write down the name and location of the hospital as well. Each question provided with linear scale response from 1-5 (very low degree to very high degree). We disseminated the questionnaire link at least 5 days to be filled by panelists and targeted 30 responses.

Data analysis
The statistical test (t-test) and some correlation studies were carried out to get a conclusion from data response. The idea is to counter any difference success factors between highly effective maintenance organization and relatively low effective maintenance organization as well as maintenance implementation by the organizations.

4. Data Collection
Data collection was carried out through a questionnaire that was submitted to hospital employees in various regions in Indonesia. The types of hospitals consisted of regional public hospitals and private hospitals. The questionnaire was filled in, among others, by doctors, nurses, management, procurement functions, etc. Of the 36 answers to the questionnaire received, only 30 could be accepted and used for analysis.

Participating organizations segmented by owner
From 30 answers to the questionnaire, it is known that most respondents came from private hospitals, namely around 67%, 20 hospitals. The remaining 33% or 10 hospitals are owned by the government.

Participating organizations segmented by region
The survey includes hospitals located in Java and outside Java. Of the 30 answers to the questionnaire received, 22 hospitals or 73% are in Java, which are in Jabodetabek, 15 hospitals, Central Java 5 hospitals and West Java 2 hospitals. Meanwhile, the 8 hospitals outside Java consist of two hospitals in North Sumatra, and the rest are one each in Ambon, Balikpapan, Batam, Lampung, Padang and Pekan Baru.

Position of respondents
Most of the respondents in the questionnaire were hospital doctors (57%, from 17 hospitals). Furthermore, 5 respondents are nurses, 3 respondents are physiotherapists, 2 respondents are from hospital management and the rest are nutritionists, head of the nursing & medical support section and lastly from the procurement function. Due to time constraints, the survey cannot be carried out directly to the maintenance department but is represented by employees working in the hospital who are expected to know the conditions of maintenance in the hospital.

The key ingredients of an effective maintenance management program
The respondents were divided into two groups, namely the highly effective and relatively low effective maintenance management. The group was divided based on the average value of all questionnaire variables for each hospital against the average total variables and hospitals. The total mean is 3.82, if the average of a hospital is less than 3.82 it is assumed to have low effective maintenance and if it is more than 3.82 it has very effective maintenance.

5. Results and Discussion
A simple test of significance was performed to identify the factors relating to highly effective maintenance management. Tests were carried out using 2 sample t-tests with the first sample being highly effective maintenance management and the second sample being low effective maintenance management. The score of each factor was calculated from the score of each variable provided by the respondents, as mentioned by Cramer (1998) and Fink (1995). The analysis was performed using Minitab software with a 95% confidence level. If the p-value is lower than 0.05 ($\alpha = 0.05$), then the factor is significantly related to highly effective maintenance management.

5.1 Numerical Results

Analysis of the significance of factors associated with high effective maintenance management
The results of the analysis show that all factors are strongly associated with highly effective maintenance management. As shown in table 1, the p-value of all factors is less than 0.05, which means that all factors are very significant related to highly effective maintenance management.

Table 1. Factors associated with high effective maintenance management

Variables	*p* value	Significance
Factor 1 Policy deployment and organization The conformity of applicable policies with hospital maintenance program standards Compliance maintenance work procedures with hospital maintenance policies The suitability of the implementation of the applicable policies	0.000	Y
Factor 2 Human Resource Management Adequacy of maintenance department personnel Competency/skills of maintenance personnel are adequate according to standards Training schedule for maintenance personnel Work load analysis periodically Availability of budget for training implementation	0.000	Y
Factor 3 Financial Aspect Suitability of maintenance cost budget (labor cost, material cost) with needs Suitability of budget with realization	0.000	Y
Factor 4 Task planning and scheduling Maintenance schedule and program according to maintenance needs Maintenance schedule and program conformity with its implementation Periodic review of the maintenance program and schedule that has been prepared	0.000	Y
Factor 5 Contracting out maintenance The third party carries out work in accordance with the scope of work required in the contract The accuracy of the type of work that is represented by a third party Maintenance reports from third parties to the person in charge of the hospital Periodic reviews of the performance of third parties Fulfillment of third party competencies with the scope of work to be carried out	0.000	Y
Factor 6 Spare Part Management The conformity of the quality of the available spare parts to the required specifications Adequacy of spare parts storage and compliance with standards Periodic reviews of the need and availability of spare part stocks Equipment spare part repair program Availability of spare parts when needed	0.000	Y
Factor 7 Maintenance approach Suitability type of maintenance with needs Establishment root cause analysis on the occurrence of equipment failure	0.000	Y
Factor 8 Information management and computerized maintenance management systems (CMMs) The maintenance information system assistance in the maintenance control process Application of the maintenance information system for all maintenance activities	0.000	Y

Note: X = the factors are not significantly related to highly effective maintenance management; Y = the factors are significantly related to highly effective maintenance management.

Analysis of correlation between the maintenance success factors
To study the relationship between maintenance success factors, the Pearson-correlation test was adopted. Pearson correlation calculations were performed using Minitab and the results are shown in table 2.
Cramer (1998) stated that if the correlation value is in the range 0.4 - 0.6 is moderate, while the correlation value more than 0.7 is considered to have a strong correlation. The correlation value of maintenance success factors in table 2 shows that factor 2 (F2) Human Resource Management and factor 4 (F4) Task planning and scheduling, have the

strongest correlation (0.894) among other success factors correlations. While the correlation with the lowest value is 0.601 or has a moderate correlation is factor 1 (F1) Policy deployment and organization with a factor 8 (F8) Information management and computerized maintenance management systems (CMMs).

Table 2. Correlation between maintenance success factors

	F1	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**
F1	1	0.753	0.866	0.717	0.653	0.741	0.682	**0.601**
F2	0.753	1	0.859	**0.894**	0.737	0.810	0.851	0.711
F3	0.866	0.859	1	0.846	0.720	0.880	0.774	0.715
F4	0.717	**0.894**	0.846	1	0.820	0.798	0.865	0.726
F5	0.653	0.737	0.720	0.820	1	0.700	0.628	0.651
F6	0.741	0.810	0.880	0.798	0.700	1	0.727	0.753
F7	0.682	0.851	0.774	0.865	0.628	0.727	1	0.782
F8	**0.601**	0.711	0.715	0.726	0.651	0.753	0.782	1

Notes: F1= Policy deployment and organization; F2= Human Resource Management; F3= Financial Aspect, F4= Task planning and scheduling; F5= Contracting out maintenance; F6= Spare Part Management; F7= Maintenance approach; F8= Information management and computerized maintenance management systems (CMMs)

5.2 Graphical Results

Based on the survey results, a radar diagram was created which was divided into 8 measurement areas (the key to successful maintenance). From the diagram for each area, the respondents were divided into four groups, namely:

1) Innocence: The hospital has not pursued good maintenance practices
2) Understanding: The hospital has applied some good maintenance practices but still needs improvement
3) Obedient: The hospital has applied good maintenance practices and complied with maintenance policy
4) Excellence: The hospital has applied good maintenance practices and has made continuous development efforts

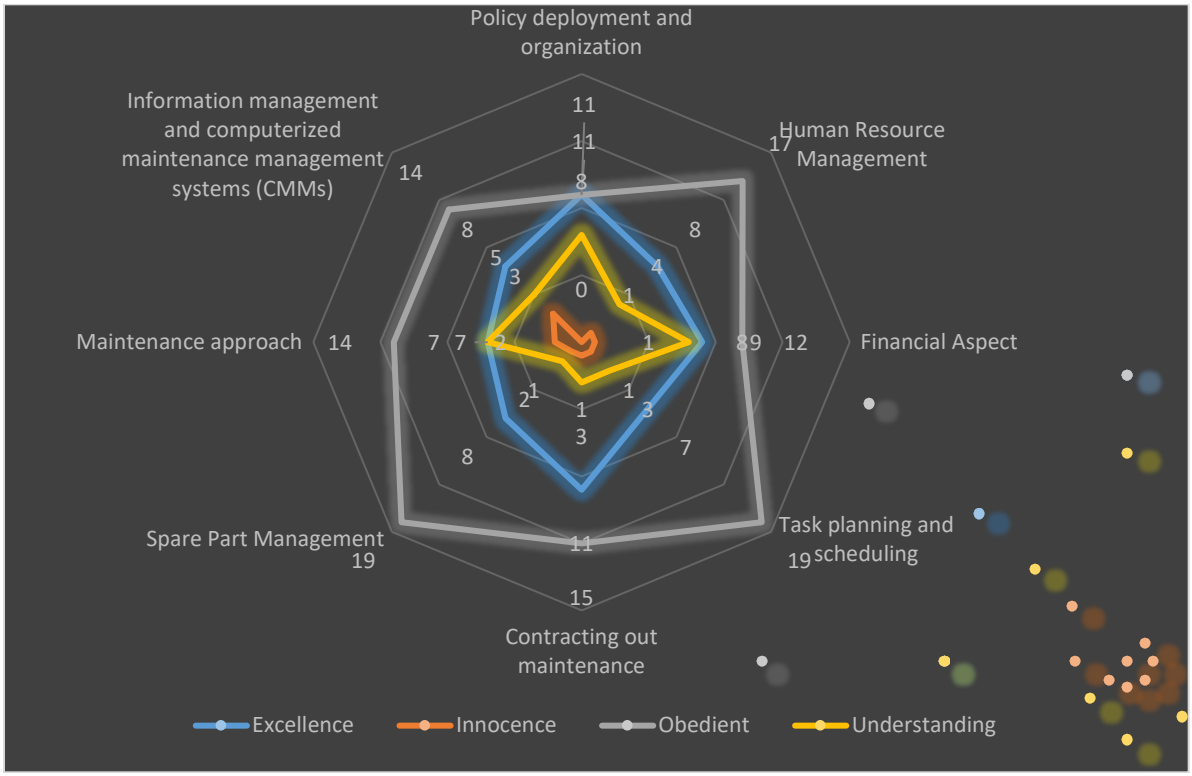

Figure 1 Radar diagram of maintenance status from survey

Figure 1 shows the status of maintenance implementation practices obtained from the hospital survey results. In implementing policy deployment and organization, all hospitals have implemented good maintenance practices, but there are eight hospitals that still need improvement. There is one hospital that has not implemented (innocence) both Human Resource Management, Financial Aspect, Task planning and scheduling, Contracting out maintenance and Spare Part Management. Information management and computerized maintenance management systems (CMMs) factors are the least widely applied factors in maintenance practices by three hospitals followed by maintenance approach by two hospitals. The most widely applied factors in maintenance practice are task planning & scheduling and spare part management, which are implemented by 19 hospitals.

Status of Hospital Maintenance Management in Indonesia

From the survey result, we can get the overview of hospital maintenance management practice in Indonesia. An accession of maintenance management level can be seen in Figure 2. We classified the respondent into four different quadrants, the poor, the fighters, the blooms and the conquerors. The better execution and benefit gained from maintenance management practice, the higher level of respondent will be. The percentage of good maintenance practice occupied is performed as horizontal axis and the percentage of benefit gained from maintenance practice (effectiveness of maintenance management) demonstrated on vertical axis.

The percentage of good practice occupied are calculated from variables of each maintenance success factor mentioned in Table 1, and benefit of maintenance practice are calculated from level of effectiveness of maintenance in many aspects, such as level of maintenance satisfaction as well as benefit from CMMs etc.

Fifty (50) percent of respondents acknowledged as the conqueror as they occupy good maintenance practice and thoroughly aware the benefit of effective maintenance management program. Seven (7) percent of respondents classified as the blooms where they already gained benefit from the practice even though they need evolving more maintenance implementation practice in their environment. Forty three (43) percent of respondents categorized as the poor who poorly implement maintenance management program thus they cannot sense the benefit of the practice. But no organization recognized as fighter who has implemented maintenance practice but sense little benefit from them.

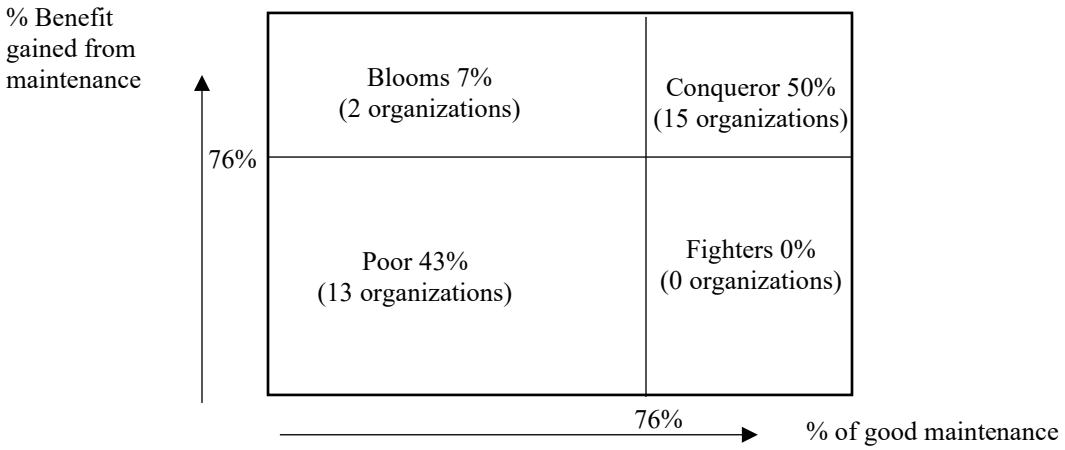

Figure 2 Maintenance Accession Level

6. Conclusion

A total of eight maintenance factors, consisting of 27 variables were considered in the questionnaire. The analysis show that all factors are strongly associated with highly effective maintenance management. From correlation analysis, human resource management and task planning and scheduling, have the strongest correlation (0.894) among other success factors correlations. While the correlation with the lowest value is 0.601 or has a moderate correlation is factor policy deployment and organization with information management and Computerized Maintenance Management systems (CMMs).

The radar diagram shows that all hospitals have implemented good policy deployment and organization. Information management and computerized maintenance management systems (CMMs) factors are the least widely applied factors in maintenance practices and the most widely applied factors in maintenance practice are task planning & scheduling and spare part management.

Further studies can be carried out by conducting a direct survey to the hospital maintenance department and also other sections for comparison. In addition, it is possible to select different key parameters in an effective maintenance management program, for example the class of the hospital.
Further studies can be carried out by adding factors related to effective maintenance management such as continuous improvement of a maintenance.

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