# Cross-Sectional Investigation of Implementing Ubiquity Mobile Maintenance Management Systems: The Healthcare Clinics Case

# ABSTRACT

Recent studies regarding mobile maintenance management systems focus on an organization’s specific industries, processes, and technologies. However, there is a recognized need for further investigation of mobile maintenance management systems in decentralized organizations with branches across the country. This study is based on data gathered from the organization’s information system. We examined the effect of implementing real-time mobile maintenance management systems. A cross-sectional investigation showed unique preventive and corrective maintenance analysis via eight repair types in healthcare clinics. In addition, gamma analysis showed that after implementing the new system, the duration of maintenance time reduced significantly for all maintenance types. Furthermore, Poisson analysis indicated that the users adopted the new system, as shown by an increase in the number of service calls. Embracing the new system strongly affects both maintenance time and extent of use, mainly in three categories of repairs: (1) carpentry and frames, (2) electrical, and (3) sanitation. The operational contribution is the feasibility of using a digital maintenance system according to the organization’s needs and types of maintenance and repairs. Furthermore, the research facilitates practical knowledge for managers in decentralized organizations.

# 1 Introduction

The research aim is to investigate the effect of implementing information communication technologies (ICT) in service organizations. The study examines the improvements in various operational activities by analyzing the gap created in several maintenance indicators before and after implementing a mobile maintenance management system (MMMS). The cross-sectional analysis conducted on various maintenance and repair types allows for imparting specific insights.

This study examines the integration of digital systems into service organizations and is based on real-life maintenance data, adding to the research knowledge in the ICT and maintenance fields. The information obtained in the research provides valuable insights and practical tools for managers. The practical knowledge will assist in deciding on the degree of economic viability in implementing a digital system that serves maintenance activities. In addition, an in-depth examination of the findings of using a digital system will improve the ability to decide which combination of maintenance and repair types contributes significantly to improving maintenance efficiency.

Many studies have examined maintenance management systems (e.g., Fu et al., 2004; Labib, 1998; Mendes et al., 2022; Wienker et al., 2016). However, MMMS is a new classification that has hardly been explored (Sumaila & Bahsi, 2022), and there is limited literature concerning mobile apps (Jantunen et al., 2010; Schoenherr, 2016; Shiau et al., 2019). The small number of quantitative studies in the field stems from the difficulty of retrieving mobile app data. In addition, organizations are reluctant to share internal data with external parties (Zhang et al., 2016).

Research on MMMS usually focuses on a specific domain (Arnaiz et al., 2006; Costa & Lopes, 2021; Jantunen et al., 2010; Lin et al., 2011; Selvakumaran et al., 2022; Sumaila & Bahsi, 2022). For instance, Lin et al. (2011) developed an MMMS based on radio frequency identification (RFID) for a Taiwan construction lab to improve instrument inspection maintenance. Jantunen et al. (2010) identified the importance of MMMS on the shop floor. Olasumbo et al. (2019) analyzed a case study of implementing an MMMS in a production environment to minimize breakdowns in production. The MMMS improved communication, knowledge, data gathering, and support to the production line. Sumaila and Bahsi (2022) explored MMMS for the automotive industry. The common ground in these studies is analyzing MMMS in a centralized organization for a specific area. Our research contributes to investigating MMMS implementation in a complex and decentralized organization. Therefore, the main research question is: *Does the implementation of an MMMS improve the performance of a maintenance department in eight types of activities in a decentralized organization?* The uniqueness of the current study is by addressing the facilities’ maintenance activities in two dimensions: (1) corrective and preventive maintenance and (2) in the context of eight types of maintenance activities in a decentralized large healthcare organization with branches across the country. To the researchers’ best knowledge, MMMS has not previously been explored in a decentralized healthcare organization.

This research offers three main contributions: (1) It adds to research knowledge using real-life maintenance data and an innovative model via cross-sectional analysis. To the authors’ knowledge, little previous research in this field has been based on real data. (2) It explores operational knowledge for decentralized organizations in the context of both corrective and preventive maintenance, covering eight repair types. (3) It identifies the business value of MMMS in improving service efficiency throughout operations effectiveness and the internal environment.

The following subsections summarize the literature regarding relevant technologies and maintenance activities, provide a general description of the healthcare clinics’ MMMS, and detail the hypotheses development related to reducing maintenance time and increasing the number of service calls. Section 2 details the material and methods used in this study. Section 3 details the study’s findings. Finally, Section 4 provides a summary with a discussion of the key findings and limitations of the study, and future implications for research and practice.

# 1.1 Literature review

Information communication technologies (ICT) facilitate transparency, ubiquitous in real-time via organizational systems integration and mobile devices that enable employees to work outside the office (Ikumapayi et al., 2022; Manyika et al., 2013; Muzafar & Jhanjhi, 2020). ICT enhances operational activities between supply chain partners in maintenance, warehousing, and logistics (Hu et al., 2015). A computerized maintenance management system is one example of the effective use of ICT (Ismail, 2021). In building facilities management, ICT enables maintenance employees to access maintenance management systems, giving them precise information regarding faults and history (Su, 2009). Su (2009) demonstrated an ERP system that enabled field workers to conduct daily maintenance activities, enabling the transfer of information with minimum paperwork (Giessmann et al., 2012). ICT for maintenance activities is essential, since field workers and technicians can receive information in real time regarding the fault and the inspection schedule, as well as read machine information from a remote location (Ikumapayi et al., 2022; Muzafar & Jhanjhi, 2020).

Maintenance refers to the operational and administrative actions required to keep facilities in the proper condition for efficient work (Pintelon & Van Puyvelde, 2006) with minimum costs (Kelly, 1989; Kumar et al., 2013). Facilities management is an integral part of operations and maintenance activities (Bouabdallaoui et al., 2020). More than 60% of the expenses of physical assets are related to operation and maintenance requests (Garg & Deshmukh, 2006; Liu & Issa, 2016; Madureira et al., 2017). For instance, Garg and Deshmukh (2006) indicated that electricity and maintenance costs account for the most significant share when planning the operational budget.

The high costs of operational and maintenance activities are due to inefficient work practices (Zhan et al., 2018). According to Yousefli et al. (2017), inefficiency in process and maintenance is even more strongly emphasized in hospitals and clinics. As a result, employees and patients feel discomfort and dissatisfaction (Yousefli et al., 2017). According to Bortolini and Forcada (2020), the dissatisfaction mainly stems from maintenance issues such as electrical, heating, ventilation, and air conditioning. Business organizations and healthcare facilities have understood for many years the importance of managing operations and maintenance requests from employees and customers (Garg & Deshmukh, 2006; Madureira et al., 2017; Yousefli et al., 2017).

Maintenance management systems in industrial organizations, hospitals, and clinics hold and manage requests for preventive and corrective maintenance faults (Ahmad & Kamaruddin, 2012; Chen et al., 2017; Gómez-Chaparro et al., 2020; Hamdi et al., 2012; Zaher et al., 2011). Mustapha and Agbevade (2011) stated that corrective maintenance requests are the most frequent request types in hospitals and clinics. Corrective maintenance requests refer to unexpected faults or non-scheduled activity in equipment or machines. Faults should be fixed as quickly as possible to facilitate continued regular operation (Chen et al., 2017; Sheut & Krajewski, 1994; Vathoopan et al., 2018).

Resolving maintenance requests quickly reduces employee and patient discomfort and dissatisfaction (Bortolini & Forcada, 2020). Examples of maintenance requests include problems with automated doors that will no longer open, broken furniture, and air conditioning and ventilation problems (Bortolini & Forcada, 2020; Gómez-Chaparro et al., 2020). Typically, maintenance requests are opened by the employees who encounter the fault. Preventive maintenance requests refer to scheduled, periodic, or planned maintenance to prevent incidents and disruption by recurrent inspections of equipment and machines while they are in good working condition (Almomani & Alburaiesi, 2020; Kannan, 2020; Zaher et al., 2011). Preventive maintenance is regularly used for healthcare equipment and widgets (Almomani & Alburaiesi, 2020; Gómez-Chaparro et al., 2020). Physical asset problems, electronic faults, and dangerous situations can be minimized by preventive maintenance (Balaras & Argiriou, 2002; Bortolini & Forcada, 2020; Surveyors, 2000).

Maintenance requests are generated daily, and the maintenance team deal with the faults according to their priority in the maintenance management system (Almomani & Alburaiesi, 2020; Becerik-Gerber et al., 2012). The maintenance management system records the maintenance request along with the description, urgency, location, and category of the fault (Bouabdallaoui et al., 2020; Federspiel, 2000; Gunay et al., 2019; Yang et al., 2018), such as electrical, heating, ventilation, or air conditioning (Bortolini & Forcada, 2020; Gómez-Chaparro et al., 2020). A maintenance management system is used for preventive and corrective maintenance, calculating the mean time between faults and downtime and producing reports (Almomani & Alburaiesi, 2020). Despite the integration of information systems, in most cases, the implementation was unsuccessful and did not improve the maintenance requests process (Bouabdallaoui et al., 2020; Ismail, 2021; Koch et al., 2018).

Maintenance optimization and improvement refers to analysis from mathematical models (de Jonge & Scarf, 2020). An optimal periodic inspection model for failure was based on a hypothetical example using the gamma process (Abdel-Hameed, 1987). Van Noortwijk (2009) suggested using the gamma process as a model for optimizing maintenance, and this has been proven to be useful in determining optimal inspection and maintenance decisions. Optimal maintenance decisions can be made by using the gamma process because of its variety of uses (Kallen & Van Noortwijk, 2005). Another maintenance model for managing the failure behavior of technical systems, in particular electrical and electronic faults, uses the Poisson process (Hosseini et al., 1999). The Poisson process is a good basis for research that predicts the corrective maintenance of other failure process types (Andrzejczak et al., 2018).

# 1.2 Healthcare clinics maintenance management system: general description

This section demonstrates how Israeli healthcare clinics manage maintenance requests regarding physical assets and service maintenance. The maintenance team is responsible for 458 clinics in five areas. The seven most common repair types refer to (1) building, (2) carpentry and frames, (3) sanitation, (4) electrical, (5) paintwork, (6) air conditioning and ventilation, and (7) refrigeration. The maintenance department is responsible for the physical assets and service maintenance requests. All maintenance requests are categorized as preventive or corrective maintenance and prioritized from low to immediate activities. Maintenance requests are addressed according to their priority. For instance, electrical faults that put employees or patients at risk have a higher urgency than carpentry maintenance requests. Only employees can open maintenance requests.

The employee uses an iPad equipped with the maintenance management system and opens a service call about the fault with detailed information such as location, fault description, corrective or preventive request, repair type, and priority. The request is automatically transferred to a call center that monitors the open service calls and passes the request to the maintenance department. The maintenance department employs ten technicians and a manager, all with relevant qualifications. The technicians receive a work plan for the day; usually, they go to the clinics in pairs. After a malfunction is fixed, the technicians close the request and the manager records the service call as resolved. If the technicians identify an additional potential problem, they open a service call with the iPad and amend it, and the manager terminates the request. The process is detailed in Figure 1. The maintenance department’s performance is measured by the average time between opening and terminating requests.

# 1.3 Hypothesis development

It is possible to reduce the repair time to a minimum and, thus, reduce the downtime of systems (Sahoo & Liyanage, 2008). Deploying an MMMS reduces repair time by decreasing the time taken to communicate about production problems and by improving the quality of shared information (Mohammadfam et al., 2014). Thus, we propose the following hypothesis:

Hypothesis 1.a: Maintenance time will reduce after implementing the MMMS.

Preventive and corrective maintenance operations require different amounts of time to resolve (Marquez & Heguedas, 2002). Preventative maintenance is based on a schedule and includes regular repairs and periodic replacements that can reduce repair time and downtime (Onoshakpor, 2014). Furthermore, the policy of preventive replacements performed at fixed times makes it possible to implement logistics in decentralized organizations with large populations and geographical dispersion (Bajestani & Banjevic, 2016). Thus, we propose the following hypothesis:

Hypothesis 1.b: The reduction of maintenance time after implementing the MMMS will be different for corrective and preventive maintenance.

Previous studies mainly analyzed the effects of MMMS according to maintenance type (Bajestani & Banjevic, 2016; Marquez & Heguedas, 2002) and activity environment (Sidibé et al., 2016). For example, Sidibé et al. (2016) investigated a model that refers to system maintenance time according to its activity environment. To the best of the authors’ knowledge, previous studies have not investigated the impact of MMMS implementation by repair type. Thus, we propose the following hypothesis:

Hypothesis 1.c: The reduction of maintenance time after implementing the MMMS will be different depending on the repair type.

Organizations that create new ways of communicating through apps increase customer engagement (Wang et al., 2015). Furthermore, enterprise applications increase communication and integration between an organization’s systems (Levi-Bliech et al., 2018). A study conducted in five different organizations that started using a mobile application showed improvements in responding to customer preferences (Pousttchi & Habermann, 2009). Therefore, we propose that implementing the MMMS will increase the end users’ use of the process of requesting maintenance services. Hence, the next set of hypotheses is proposed.

Hypothesis 2.a: The number of calls per week for maintenance services will increase after implementing the MMMS.

Hypothesis 2.b: The increase in the number of calls per week for maintenance services after implementing the MMMS will differ between corrective and preventive maintenance.

Hypothesis 2.c: The increase in the number of calls per week for maintenance services after implementing the MMMS will differ by repair type.

2 Material and methods

## 2.1 Data collection

Data of 6,997 maintenance records were collected over 167 weeks from the organizational databases included for each maintenance service call. Fields extracted included “Start maintenance service time,” “Finish maintenance service time,” and “Repair type.” Few studies on maintenance have been based on real-world scenarios (de Jonge & Scarf, 2020).

The dataset was based on a period of four years (from January 1, 2017 to December 31, 2021). A total of 2,465 records (35.2%) were collected before the implementation period (from September 1, 2019 to December 30, 2021) and 4,532 (64.7%) records were collected after implementation.

## 2.2 Descriptive statistics

Tables 1 and 2 present the descriptive statistics for maintenance time and service calls, respectively. The Repair Type column describes the various repair types; the Period Time column defines the time before and after the system implementation; the next columns contain data on group sample size and the means and standard deviations of the dependent variables (DVs). The DVs examined in the three comparisons are: (i) total maintenance time and service calls; (ii) corrective maintenance time and service calls; and (iii) preventive maintenance time and service calls.

**[[Place Table 1 about here]]**

**[[Place Table 2 about here]]**

## 2.3 Data analysis

H1.a and H1.b were tested with the DVs of the maintenance team’s mean resolution time before and after implementation (N = 1,844 in model (1); N = 644 in model (2); N = 1,636 in model (3)). The DVs represent the time that it took for the manager to close the maintenance activities manually (before implementation) compared to after the implementation of the MMMS. H2.a and H2.b were tested using the count of maintenance activities per week as the unit of analysis (N = 1,844 in model (4); N = 644 in model (5); N = 1,636 in model (6)). A gamma regression was used in models (1)–(3), and Poisson regression was used in models (4)–(6). The dependent variable before and after implementation was categorized as binary.

Models (1) and (4) refer to total maintenance activities, models (2) and (5) refer to corrective maintenance activities, and models (3) and (6) refer to preventive maintenance activities (Table 3). We tested the gamma and Poisson regressions with before and after system implementation as the principal variable.

**[[Place Table 3 about here]]**

H3.a and H3.b were tested by *t*-test for two independent samples (before and after system implementation). Table 4 presents the results of the *t*-tests for all the DVs. The first column describes the repair types. The next columns show the mean difference in the two DVs in the three comparison groups. Tables 1 and 2 present the mean and SD for each DV.

**[[Place Table 4 about here]]**

Figures 2 and 3 present three panels corresponding to the three comparison groups of maintenance. The plots show the differences in the DVs before and after system implementation for each repair type.

**[[ Place Figure 2 about here ]]**

**[[ Place Figure 3 about here ]]**

# 3. Results

The results given in Table 3 confirm that the H1.a and H1.b hypotheses were significant and negative after implementing a new system for models (1)–(3) and positive for models (4) and (6). These findings suggest that after implementing the MMMS, the mean resolution time was reduced while the volume of service calls for maintenance activities per week increased. The negative and positive effects result from the new system’s capabilities such as availability, data visibility, and connectivity to the call center and technicians. The results in Table 3 did not support H2.b with model (5), implying that the new system did not affect the number of calls related to corrective maintenance activities opened each week. This finding stems from the fact that failures or malfunctions occur randomly and are resolved by corrective maintenance (Pal & Adhikari, 2021; Scutariu & Albert, 2006).

The results in Table 4 show that hypothesis H1.c is significant for several repair types. The results for building, carpentry and frames, electrical, other facilities, and sanitation show that maintenance time was reduced after implementing the new system in all three maintenance activities. The effect on repairs to air conditioning, paintwork, and refrigeration was insignificant after the MMMS implementation. The results in Table 4 indicate that hypothesis H2.c is significant. Thus, the number of calls for maintenance services after the implementation increased in three repair types: building, carpentry and frames, and sanitation. No significant evidence was found in the repair types of air conditioning, other facilities, paintwork, or refrigeration. A unique outcome was found in the building repair type, which showed that the number of calls for maintenance services after implementation reduced.

# 4. Discussion and conclusions

Our research represents two DVs of maintenance: time and service call. The DVs were analyzed with three comparison maintenance groups – total, corrective, and preventive – cross-sectionally aganst eight repair types. The data were collected by SAP software and tested with three statistical models: gamma and Poisson regressions and a *t*-test for two independent samples.

This research has two key findings. The first refers to improved maintenance times (H1.a, H1.b, and most of H1.c). After implementing the new MMMS, the length of maintenance time reduced significantly for all maintenance types. The negatively affected repair types related to preventive maintenance activities. Hence, the MMMS improves service efficiency in two organizational environments. First, operational efficiency improves the internal environment – for example, clinical personnel receive accessible and real-time information about their patients without computer malfunctions, and the medicine refrigerators work in an improved and more efficient manner and sustain the integrity of medicines and vaccines. Second, customer service improves the external environment – for example, the patient receives administrative aid and medical treatment at the appointed time without a delay when the information and electrical systems are working correctly. In addition, when air conditioning and plumbing systems function correctly, the patient has a more pleasant stay and experience.

The second key finding refers to the increase in the frequency of maintenance service calls via the new MMMS (H2.a and H2.b). The positive effect strongly impacted three repair types (1) carpentry and frames, (2) electrical, and (3) sanitation (H2.c). The MMMS is more friendly and accessible than the old process. In addition, the clinics’ employees (end users) have an easy-to-use way to request the maintenance teams in real-time. As a result, the handling of maintenance activities is carried out more frequently and improves the clinics’ operation (internal environment) and the patient experience (external environment).

Our research has three main limitations that open avenues for future research. The first limitation refers to the empirical data, which is based only on a single organization from the health sector in Israel. Therefore, future research should explore organizations from various industries and countries. The second limitation refers to the limited period over which the impacts of the system implementation were measured. Future studies should be based on longitudinal studies that will allow for measuring operational performance over a longer period. The third limitation refers to the outcome of the current study. When an organization implements new ICT, managers should use restraint when redesigning operational processes. These results should be used carefully until more research explores them for various organizations.

The study’s contributions are both conceptual and operational. The conceptual contribution to research is using real-life maintenance data and inventive profound model analysis. The unique model investigated the impacts of implementing MMMS according to the type of maintenance and treatment by cross-comparison analysis. We examined the effects of the system by measuring the gap in maintenance time and the number of service calls per week on three levels: (1) total maintenance, (2) type of maintenance, and (3) repair type via maintenance type. As a result, we open an avenue for future research in maintenance and ICT.

The operational contribution allows organizations to decide on the feasibility of using a digital maintenance system according to the organization’s repair needs and types of maintenance. The system implementation enables the optimization of maintenance resources in decentralized organizations, minimizes the maintenance department’s staff, and improves operational efficiency. For instance, the standard resolution time of several repair types can be reduced and, as a result, may decrease the human capital of the maintenance department and the waste of operational systems. The outcome is a reduction in overhead costs; correspondingly, operational improvement increases customer satisfaction and retention.

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# Tables

Table 1: Descriptive statistics of Maintenance time

|  |  |  |
| --- | --- | --- |
| Repair Type | Period Time(Before and After implementation) | DV: Maintenance time (days) |
| Total Maintenance |  Corrective Maintenance  | Preventive Maintenance |
| Sample size | Mean | SD | Sample size | Mean | SD | Sample size | Mean | SD |
| Aiֹr condition | Before implementation | 3 | 13.44 | 5.68 | 2 | 16.72 | 0.27 | 1 | 6.89 | 0 |
| After implementation | 16 | 9.73 | 7.31 |  |  |  | 16 | 9.73 | 7.31 |
| Building | Before implementation | 290 | 12.50 | 6.14 | 191 | 11.96 | 6.45 | 260 | 12.72 | 6.32 |
| After implementation | 78 | 8.66 | 7.11 | 18 | 4.61 | 5.86 | 67 | 9.45 | 7.27 |
| Carpentry and frames | Before implementation | 188 | 11.80 | 6.35 | 56 | 11.14 | 6.19 | 166 | 12.15 | 6.55 |
| After implementation | 287 | 8.75 | 5.80 | 93 | 9.00 | 6.52 | 285 | 8.76 | 5.82 |
| Electrical facilities | Before implementation | 183 | 12.06 | 6.42 | 61 | 12.50 | 7.30 | 159 | 12.23 | 6.79 |
| After implementation | 280 | 8.98 | 6.36 | 49 | 7.90 | 6.76 | 278 | 9.06 | 6.52 |
| Other facilities | Before implementation | 27 | 13.25 | 8.79 | 13 | 11.87 | 8.82 | 14 | 14.53 | 8.89 |
| After implementation | 51 | 9.41 | 8.26 | 10 | 10.80 | 6.34 | 42 | 9.08 | 8.60 |
| Paint works | Before implementation | 3 | 16.14 | 8.85 | 3 | 16.14 | 8.85 | - | - | - |
| After implementation | 37 | 11.76 | 8.29 | 3 | 9.04 | 4.99 | 34 | 12.00 | 8.53 |
| Refrigeration facilities | Before implementation | 3 | 13.27 | 9.42 | 1 | 2.54 | 0 | 2 | 18.64 | 2.13 |
| After implementation | 10 | 9.09 | 6.30 | 1 | 13.87 | 0 | 9 | 8.56 | 6.44 |
| Sanitation facilities | Before implementation | 119 | 11.29 | 6.78 | 86 | 10.91 | 6.77 | 47 | 12.22 | 7.25 |
| After implementation | 269 | 8.75 | 6.22 | 77 | 7.95 | 5.95 | 256 | 8.89 | 6.49 |
| Total | Before implementation | 816 | 12.11 | 6.46 | 413 | 11.74 | 6.70 | 649 | 12.47 | 6.62 |
| After implementation | 1028 | 8.96 | 6.44 | 251 | 8.24 | 6.38 | 987 | 9.06 | 6.57 |
| Total all | 1844 | 10.35 | 6.63 | 664 | 10.42 | 6.80 | 1636 | 10.41 | 6.79 |

Table 2: Descriptive statistics of Maintenance calls

|  |  |  |
| --- | --- | --- |
| Repair Type | Period Time(Before and After system implementation) | DV: Maintenance calls (Number calls per week) |
| Total Maintenance | Corrective Maintenance  | Preventive Maintenance  |
| Sample size | Mean | SD | Sample size | Mean | SD | Sample size | Mean | SD |
| Aiֹr condition | Before implementation | 3 | 1.33 | 0.58 | 2 | 1.50 | 0.71 | 1 | 1.00 | 0 |
| After implementation | 16 | 1.06 | 0.25 |  |  |  | 16 | 1.06 | 0.25 |
| Building | Before implementation | 290 | 5.00 | 4.17 | 191 | 2.35 | 2.81 | 260 | 3.85 | 3.55 |
| After implementation | 78 | 1.42 | 0.80 | 18 | 1.00 | 0.00 | 67 | 1.39 | 0.70 |
| Carpentry and frames | Before implementation | 290 | 2.32 | 1.61 | 56 | 1.64 | 1.59 | 166 | 2.07 | 1.37 |
| After implementation | 78 | 7.29 | 4.01 | 93 | 2.17 | 1.56 | 285 | 6.64 | 3.81 |
| Electrical facilities | Before implementation | 183 | 1.98 | 1.09 | 61 | 1.39 | 0.71 | 159 | 1.75 | 0.97 |
| After implementation | 280 | 4.41 | 2.67 | 49 | 1.69 | 1.16 | 278 | 4.14 | 2.58 |
| Other facilities | Before implementation | 27 | 1.07 | 0.27 | 13 | 1.15 | 0.38 | 14 | 1.00 | 0.00 |
| After implementation | 51 | 1.12 | 0.43 | 10 | 1.30 | 0.67 | 42 | 1.05 | 0.22 |
| Paint works | Before implementation | 3 | 1.00 | 0.00 | 3 | 1.00 | 0.00 |  |  |  |
| After implementation | 37 | 1.11 | 0.31 | 3 | 1.00 | 0.00 | 34 | 1.12 | 0.33 |
| Refrigeration facilities | Before implementation | 3 | 1.00 | 0.00 | 1 | 1.00 | 0.00 | 2 | 1.00 | 0.00 |
| After implementation | 10 | 1.00 | 0.00 | 1 | 1.00 | 0.00 | 9 | 1.00 | 0.00 |
| Sanitation facilities | Before implementation | 119 | 1.39 | 0.78 | 86 | 1.30 | 0.72 | 47 | 1.15 | 0.42 |
| After implementation | 269 | 3.60 | 1.99 | 77 | 1.99 | 1.43 | 256 | 3.18 | 1.96 |
| Total | Before implementation | 816 | 3.01 | 3.07 | 413 | 1.84 | 2.10 | 649 | 2.61 | 2.62 |
| After implementation | 1028 | 4.41 | 3.45 | 251 | 1.88 | 1.38 | 987 | 4.11 | 3.26 |
| Total all | 1844 | 3.79 | 3.36 | 664 | 1.86 | 1.86 | 1636 | 3.52 | 3.11 |

Table 3: Regression results

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|   | H1.a- Total Maintenance | H1.b-Corrective Maintenance 0 | H1.b- Preventive Maintenance 1 | H2.a- Total Maintenance | H2.b- Corrective Maintenance 0 | H2.b- Preventive Maintenance 1 |
| Variable | (1) | (2) | (3) | (4) | (5) | (6) |
| Intercept | 2.494\*\*\*(0.022) | 2.463\*\*\*(0.320) | 2.523\*\*\*(0.025) | 1.101\*\*\*(0.034) | 0.610\*\*\*(0.049) | 0.959\*\*\*(0.039) |
| After Sys | -0.301\*\*\*(0.029) | -0.354\*\*\*(0.052) | -0.319\*\*\*(0.032) | 0.382\*\*\*(0.042) | 0.240(0.080) | 0.454\*\*\*(0.046) |
| Before Sys | 0 | 0 | 0 | 0 | 0 | 0 |
| Unstandardized coefficients are presented, with standard errors |   |   |   |
| N = 1844 in Models (1)-(2), (7)-(8); N = 644 in Models (3)-(4), (9)-(10);N = 1636 in Models (5)-(6), (11)-(12); |
| \* p < 0.05; \*\* p < 0.01; \*\*\* p < 0.001 |   |   |   |   |

Table 4: Comparison statistics by repair type

|  |  |  |
| --- | --- | --- |
| Repair Type | Mean diff. Maintenance time (days)((After system implementation- Before system implementation | Mean diff. Maintenance calls (Number calls per week)(After system implementation- Before system implementation) |
| Total Maintenance  | Corrective Maintenance | Preventive Maintenance  | Total Maintenance  | Corrective Maintenance | Preventive Maintenance  |
| Aiֹr condition | 3.71- |  | 2.84 | 0.27- |  | 0.63 |
| Building | \*\*\*3.84- | 7.35-\*\*\* | \*\*\*3.27- | \*\*\*3.58- | \*\*\*1.35- | \*\*\*2.46 |
| Carpentry and frames | \*\*\*3.05- | 2.14-\*\* | \*\*\*3.38- | \*\*\*4.97 | \*\*0.53 | \*\*\*4.56 |
| Electrical facilities | \*\*\*3.08- | \*\*\*4.59- | \*\*\*3.18- | \*\*\*2.42 | 0.30 | \*\*\*2.39 |
| Other facilities | \*\*3.84- | 1.08- | \*\*5.46- | 0.04 | 0.15 | 0.05 |
| Paint works | 4.39- | 7.10- |  | 0.11 |  |  |
| Refrigeration facilities | 4.18- | 11.33 | \*\*10.08- |  | 0.00 |  |
| Sanitation facilities | \*\*\*2.54- | \*\*\*2.96- | \*\*\*3.33- | \*\*\*2.20 | \*\*\*0.69 | \*\*\*2.04 |
| Total | \*\*\*3.14- | \*\*\*3.50- | \*\*\*3.40- | \*\*\*1.40 | 0.04 | \*\*\*1.51 |
| \* p < 0.05; \*\* p < 0.01; \*\*\* p < 0.001 |

# Figures

Figure 1: Detailed process of maintenance request 



Figure : Mean maintenance time by repair type for each maintenance category

Panel (i)) Total Maintenance(

Panel (ii)) Corrective Maintenance(

Panel (iii)) Preventive Maintenance(



Figure : Number of calls per week by repair type of each maintenance category

Panel (i)) Total Maintenance)

Panel (ii)) Corrective Maintenance)

Panel (iii)) Preventive Maintenance)

