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عمادة الدراسات العليا

# Key Performance Indicators for Maintenance in Hospitals buildings in Gaza Strip

# مؤشرات الأداء الأساسية لصيانة مباني المستشفيات في قطاع غزة

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قال رسول الله صلى الله عليه وسلم:

" مَنْ سَلَكَ طريقا يبتغي فيه علما سَلَكَ اللَّهُ بِهِ طريقا إلى الجنة ، وإن المَلاَئِكَةَ لَتَضَعُ أَجْنِحَتَهَا رضاء لطالب العلم ، وإن الْعَالِمِ لَيَسْتَغْفِرُ له من في السموات ومن في الأرض ، حتى الحيتَانُ في الماء ، وَفضْلُ العَالِمِ عَلَى العَابِدِ كَفَضْلِ القَمَرِ عَلَى سَائِرِ الكَوَاكِبِ ، إنَّ العُلَمَاءَ وَرَثَةُ الأنْبِيَاءِ ، إنَّ الأنْبِيَاءَ لَمْ يَوَرِّثُوا دِينَاراً وَلاَ دِرْهَماً إنَّمَا وَرَّثُوا العِلْمَ ، فَمَنْ أَخَذَهُ أَخَذَ بحَظٍّ وَافِرٍ"

# Dedication

I would like to dedicate this research to my beloved mother,

father and my two brothers for their endless support.

Also to the memory of my beloved uncle

"Osama Hasan El Khoudary" may peace rest upon him.

Farida Emad El Shorafa

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## Abstract

The health sector in Gaza Strip means a big issue in Palestinian`s life for its specialty and instability of political status which makes it imperative for leaders and managers of health sector to improve and develop this important sector. Maintenance management of hospital buildings is one of the more complex subjects in the field of facilities management (FM). It involves, planning, directing, controlling and organizing maintenance activities. Performance management aims at offering managers and members of staff of all ranks the ability to develop the direction, traction and speed of their organization.

The aim of this research is to study the maintenance performance indicators in order to control the operation of hospital building maintenance in the Gaza Strip**.** Several Key Performance Indicators (KPIs) were developed for hospital buildings, ten KPI's for hospital facilities presented, but four KPIs were used in this study to be suitable to the Gaza Strip hospitals. Another objective of this research is to study the operational conditions and factors that carried out and affect the maintenance management and deriving a suitable framework for the minimum requirements.

All the 13 governmental hospitals which are administrated by Ministry of Health was the targeted population of this research. This research has been conducted through literature reviews on the topic related to the maintenance management performance indicators, followed by a field survey and interviewed questionnaire for the thirteen hospital departments in all the Gaza Strip hospitals.

The results showed that 83.3 % of the maintenance department that maintenance activities in hospitals buildings is getting better during the last 2 years. There is no significant association between the maintenance staff users and the poor maintenance management of public hospital buildings in Gaza Strip. The BPI was for total average performance 76.18 for the 13 hospitals which is marginal status and needs preventive maintenance. The annual maintenance expenditure (AME) for the maintenance for health facilities expenditure in Gaza Strip is lag far behind. It was $13.8 per sq m, which is under the standard level of expenditure. In average, the maintenance expendtiure indicator (MEI) for Gaza hospitals was 0.3 which indicated low budgetary investment. Urgent repair index (URI) percents considered in the average percents in the hospitals.

The annual maintenance expenditure is lower 2.5 times than standard due to the poor financial status in the Palestinian hospitals.

Case studies showed that all the large scale maintenance projects classified as corrective maintenance. Applying preventive maintenance PM can be considered as success factor for implementing the framework to meet the minimum requirements for the maintenance management.

The study recommended developing a team vision for hospital maintenance department, changing the work style and culture towards maintenance, making certified periodic maintenance checklists, developing and implementing adequate KPIs for the Gaza strip hospital status.

## ملخص البحث

يعتبر القطاع الصحي في قطاع غزة جزء مهم في حياة الشعب الفلسطيني لما له من خصوصية وعدم استقرار الوضع السياسي مما يحتم على القادة والمديرين من القطاع الصحي لتكون المنشات الصحية جاهزة في أي لحظة. إدارة صيانة مباني المستشفيات هي واحدة من المواضيع الأكثر تعقيدا في مجال إدارة المرافق. حيث أنها تضم ,التخطيط ,التوجيه , السيطرة وتنظيم أنشطة الصيانة اليومية . إدارة الأداء يهدف إلى تقديم لكافة المدراء والأعضاء من جميع الرتب القدرة على تطوير منظمتهم للأفضل.

حيث أن الهدف من هذا البحث هو دراسة مؤشرات الأداء الأساسية لصيانة المستشفيات في قطاع غزة. وقد وضعت عدة مؤشرات أداء رئيسية لمباني المستشفيات، حوالي عشر مؤشرات لمرافق المستشفى ولكن تم استخدام أربع مؤشرات أداء رئيسية في هذه الدراسة لتكون مناسبة لمستشفيات قطاع غزة. و هدف اخر من هذه الدراسة لجمع الظروف التشغيلية والعوامل التي تؤثر على إدارة الصيانة و تحديد الحد الأدنى من متطلبات إدارة الصيانة.

الفئة المستهدفة لهذا البحث 13 مستشفى من المستشفيات الحكومية التي تدار من قبل وزارة الصحة . وقد أجريت هذه الدراسة من خلال استعراض الدراسات السابقة حول الموضوع ، تليها المسح الميداني و الاستبيان لأقسام صيانة المستشفيات الثلاثة عشر في جميع مستشفيات قطاع غزة الحكومية.

وأظهرت النتائج أن 83.3٪ من أقسام الصيانة في المستشفيات أن المباني في تحسن ملحوظ خلال السنوات الأخيرة(2012-2011). كما أنه لا يوجد أي ارتباط مهم بين المستخدمين لمباني المستشفي و إدارة صيانة المباني الضعيفة في المستشفيات العامة في قطاع غزة. كان متوسط الأداء لمباني المستشفيات الثلاثة عشر 76.18 أي في حالة قريبة من الحد الأدني لأداء المباني , لذا فهي في احتياج للصيانة الوقائية.

تبين من خلال البحث أن أداء نفقات الصيانة السنوية للمرافق الصحية في قطاع غزة يبلغ 13.8 $ للمتر المربع، وهو تحت مستوى الإنفاق القياسي. بينما كان مؤشر كفاءة الصيانة لمستشفيات قطاع غزة يشير إلى 0.3. حيث يدل أن الميزانية منخفضة. بينما مؤشر الاصلاح العاجل جاء بنسبة متوسطة. نفقات الصيانة السنوية 2.5 مرة أقل من المستوى القياسي بسبب الوضع المالي الفقير في المستشفيات الفلسطينية.

وأظهرت الحالات الدراسية أن جميع مشاريع الصيانة تصنف على أنها صيانة تصحيحية. ويمكن اعتبار تطبيق الصيانة الوقائية من عوامل النجاح لتلبية الحد الأدنى من المتطلبات لإدارة الصيانة.

و أوصت الدراسة بوضع رؤية واضحة لفريق قسم الصيانة في المستشفى، وتغيير نمط العمل والثقافة نحو الصيانة، وعمل قوائم صيانة دورية وتطوير وتنفيذ مؤشرات الأداء الرئيسية لتناسب مباني مستشفيات قطاع غزة.

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**List of abbreviations**

| | |
|---|---|
| ACB | Total number of acute-care patient beds in the facility |
| APi,j | Actual performance score for system j in building i |
| AME | Annual Maintenance Expenditure |
| AHU | Air Handling Units |
| BPI | Building Performance Indicator |
| CEP | Center for Engineering and Planning |
| Ci,j,k | Reinstatement value for component k of system j in building i ($US per sq m) |
| dlci,j,k | Designed Life Cycle for component k of system j in building i [years] |
| DLCi | Designed Life Cycle for building i [years] |
| FA | Total built area of the facility [sq-m] |
| FM | Facility Management |
| FC | Facility coefficient for year y |
| GR | General requests for repair of the building facilities |
| HVAC | Heating, ventilating and air-conditioning |
| int | Annual interest rate [%] |
| i | Counter of building |
| j | Counter of system (from 1 to 10) |
| k | Counter of component |
| KPIs | key performance indicators |
| LCC | Life Cycle Costs |
| LCCi,j,k | Annual Equivalent Value of Life Cycle Costs for component k of system j in building i($US per sq-m) |
| Mi,j,k | Annual maintenance cost for component k of system j in building i ($US per sq-m) |
| MOH | Ministry of Health |
| MEI | Maintenance Efficiency Indicator |
| NRi,j,k | Number of replacements during Design Life Cycle of component k of system j in building i |
| NBS | Number of buildings surveyed |
| NOB | Total number of equivalent patient beds in the facility |

| | |
|---|---|
| NGOs | Nongovernmental organizations |
| ORs | Operating rooms |
| PMMS | Palestinian Military Medical Services |
| PI | Performance Indicator |
| PM | Preventive Maintenance |
| PHC | Primary Health care |
| pr | Present value annuity factor |
| Ri,j,k | Replacement cost for component k of system j in building i ($US per sq-m) |
| rp | Annuity present value factor |
| RMD | Reusable medical device |
| sr | Future value annuity factor |
| SAL | Sterility Assurance Level |
| TOAi | Total floor area of building i (sq-m) |
| TAME | Total Annual Maintenance Expenditure ($US) |
| URI | Urgent Repair Request Index |
| UNRWA | United Nations Relief and Works Agency |
| UNDP | United Nations Development Programme |
| VCT | Vinyl composition tile |
| WHO | World Health Organisation |
| UNSCO | United Nations Educational, Scientific and Cultural Organization |
| UR | Number of urgent repair requests |

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# Chapter 1

# Introduction

## 1.1. Background

Hospitals and health care buildings are among the most complex indoor facilities with numerous different end uses of indoor spaces and functions (Balaras et al, 2007). Hospital represents perhaps the most difficult group of largely public sector buildings to maintain, because of their complex engineering services (Zawawi et al, 2010). Over the passage of time, maintenance function has continuously gone up in terms of its importance. It is recognized that since poor maintenance practices lead to more frequent breakdowns, which may cause anything from inconvenience to catastrophe, maintenance has to be more reliable, more efficient, and more cost effective (Ikhwan and Burney, 1999). The concept of maintainability was formally initiated by the military services of the United States in 1954. In the past few decades, researchers had realized the importance of maintainability of buildings in achieving cost savings and better functioning of facilities (Silva et al, 2004).

It is impossible to produce buildings which are maintenance free, but maintenance work can be minimized by good design and proper workmanship carried out by skilled experts or competent craftsmen using suitable codes of installation, requisite building materials and methods. Management of any process involves assessing performance, and maintenance management of buildings is no exception (Adenuga et al, 2007). A prime aim of building maintenance is to preserve a building in its initial effective state, as far as practicable, so that it serves its purpose effectively. The best way to achieve excellent maintenance is to have a maintenance management that matches as closely as possible the expected requirements of the user (Zawawi et al, 2010).

The importance of performance measurement cannot be over emphasized, with many authors stressing its role in today's information-driven decision making environment (Kutucuoglu et al, 2001). In the past two decades, performance measurement (PM) has received a great amount of attention from researchers and practitioners. Major issues related to this field concern what to measure and how to measure it in a practically feasible and cost-effective way. Measurement gives the status of the variable, compares the data with target or standard data and points out what actions should be taken and where they should be taken as corrective and preventive measures (Parida and Kumar, 2006).

## 1.2. **Health services** situation in Palestine

Ministry of Health (MOH) in Gaza Strip is considered the main provider of health services (primary and secondary health care). MOH believes that the Palestinian people deserve the best health services and its sustainability in all health facilities which can be achieved in improving the quality of the medical staff, maintain the health facilities buildings in good status and expanding the capacity of health facilities. Gaza Strip which is located at the southwestern part of Palestine with a total area of 360km2. According to Palestinian Central Bureau of Statistics (2011) figures in 2011 Gaza strip has a total population of 1,588,691 capita and natural increase of population rate (3.3 %). These numbers indicates that health sector must cover all the patients in Gaza strip governorates (North, Gaza, Middle, Khanyonis and Rafah).

Figure1.1 represents the MOH hierarchical which categorizing the work for general directorates and units. Engineering and maintenance classified as one of the general directorate which care of MOH facilities buildings and its installations, equipments, furniture and construction.

Ministry of health care facilities classified as follows:

- Primary health care represented in clinics
- Secondary health care represented in hospitals

There are five main health providers of health services in Palestine: Ministry of health, UNRWA, NGOs, Palestinian Military Medical Services (PMMS) and Private sector. Ministry of health report (2011) indicates that MOH bears the heaviest burden, as it has the responsibility. In the West Bank there are (669) primary health centers operated by four main providers, while in the Gaza Strip there are there are (147) distributed as follow: MOH operates (54) primary health care centers, UNRWA operates (20) primary health care centers scattered in eight refugee camps in the Gaza Strip. The NGOs sector operates (66) primary health care centers and general clinics in Gaza Strip, where PMMS operate (7) primary health care centers and clinics in Gaza Strip.

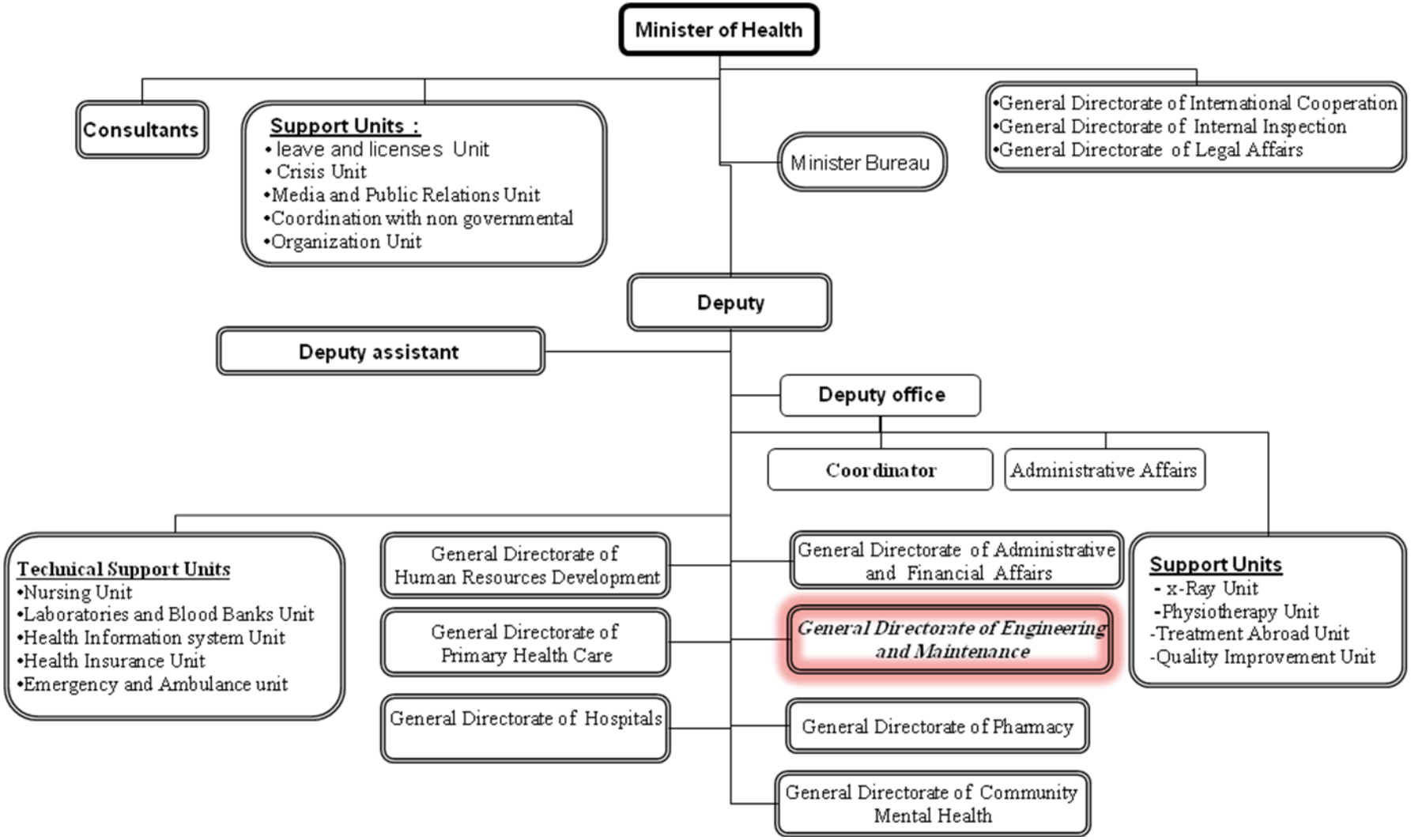


Figure 1.1 Ministry of Health hierarchical (Source: MOH reports, 2011)

The hospital services are operated by the government and non-government. There are (81) hospitals in Palestine; (51) in West Bank and (30) in Gaza Strip. Table 1 indicates that there are only three providers of secondary health care in Gaza Strip UNRWA and private sector don`t operate hospitals in Gaza strip. It represents also the number of hospitals and its bed capacities.

Table 1.1 Health services Providers and hospitals beds capacity in Gaza Strip

| Service Provider | No. of hospitals | No. of beds | %Percentage of total number of beds |
|---|---|---|---|
| MOH | 13 | 1937 | 70% |
| NGO | 14 | 655 | 23.7% |
| PMMS | 3 | 177 | 6.3% |
| UNRWA | 0 | - | 0 |
| Private | 0 | - | 0 |
| Total | 30 | 2769 | 100% |

(Source: Ministry of health annual report 2011)

Table 2 represents in numbers that there is shortage in Rafah and North governorates in health services because of high population and limited number of hospitals.

Table 1.2 Hospital distribution and hospital beds on Gaza Strip Governorates

| Governorate | Population | Total Hospitals | |
|---|---|---|---|
| | | NO. | Capita/hospital |
| North | 303,351 | 6 | 60,670 |
| Gaza | 543,195 | 14 | 38,799 |
| Middle | 226,778 | 2 | 113,389 |
| Khan yonis | 296,438 | 5 | 59,287 |
| Rafah | 192,144 | 3 | 94,048 |

(Source: Ministry of health annual report 2010)

The health sector in Gaza Strip faces several challenges like siege since 2007, war on Gaza in 2008 affects the health sector negatively and all working teams was exhausted to be on track and to offer good service to the Palestinian people and lack of budgets to improve the quality of health care. Also the small size of the hospitals and health institutions are small compared to the standard criteria for hospital building.

## 1.3. Hospitals maintenance situation in Gaza Strip

### 1.3.1. General hospital information in Gaza Strip

In Gaza strip the health sector means a big issue in Palestinian`s life for its specialty and unstability of political status which makes it imperative on leaders and managers of health sector to be ready at any moment. According to MOH reports Gaza strip contains 30 hospitals distributed in Gaza strip governorates 13 hospital is governmental which under responsibility of MOH. Table 1.3 shows the distribution of governmental hospitals.

Table 1.3 Ministry of health hospitals "governmental" (MOH report, 2011)

| No. | Hospital Name | Geographic Location | No. of Beds | Hospital Area in sq. m. | Category | Type |
|---|---|---|---|---|---|---|
| 1 | Bait Hanon | North | 45 | 2,500 | Small | General |
| 2 | Kamal Odwan | North | 104 | 5,000 | Big | General |
| 3 | Al Naser for Pediatrics | Gaza | 136 | 4,400 | Big | Specialized |
| 4 | Ophthalmic | Gaza | 42 | 3,600 | Small | Specialized |
| 5 | Psychiatric hospital | Gaza | 29 | 6,000 | Small | Specialized |
| 6 | Rantisi Specialized Pediatrics | Gaza | 51 | 2,500 | Small | Specialized |
| 7 | Dorra | Gaza | 91 | 1,600 | Small | Specialized |
| 8 | Shifa | Gaza | 619 | 42,000 | Complex | General |
| 9 | Al Aqsa | Middle | 136 | 4,000 | Big | General |
| 10 | Nasser | Khanyonis | 322 | 5,000 | Complex | General |
| 11 | European Gaza Hospital | Khanyonis | 261 | 65,000 | Big | General |
| 12 | Abo Yosef Al Najjar | Rafah | 80 | 4,000 | Small | General |
| 13 | Tal Sultan (Hilal Emarati) | Rafah | 52 | 4,000 | Small | Delivery (Maternity) |

In 2011 bed occupancy rate was 82.5%and Average length of stay for patients was 2.9 day. As noticed in the geographic allocation Gaza governorate has the most number of hospitals which include shifa hospital which considered as the biggest hospital in west bank and Gaza strip see Figure 1.2 illustrates the geographical location of governmental hospitals.

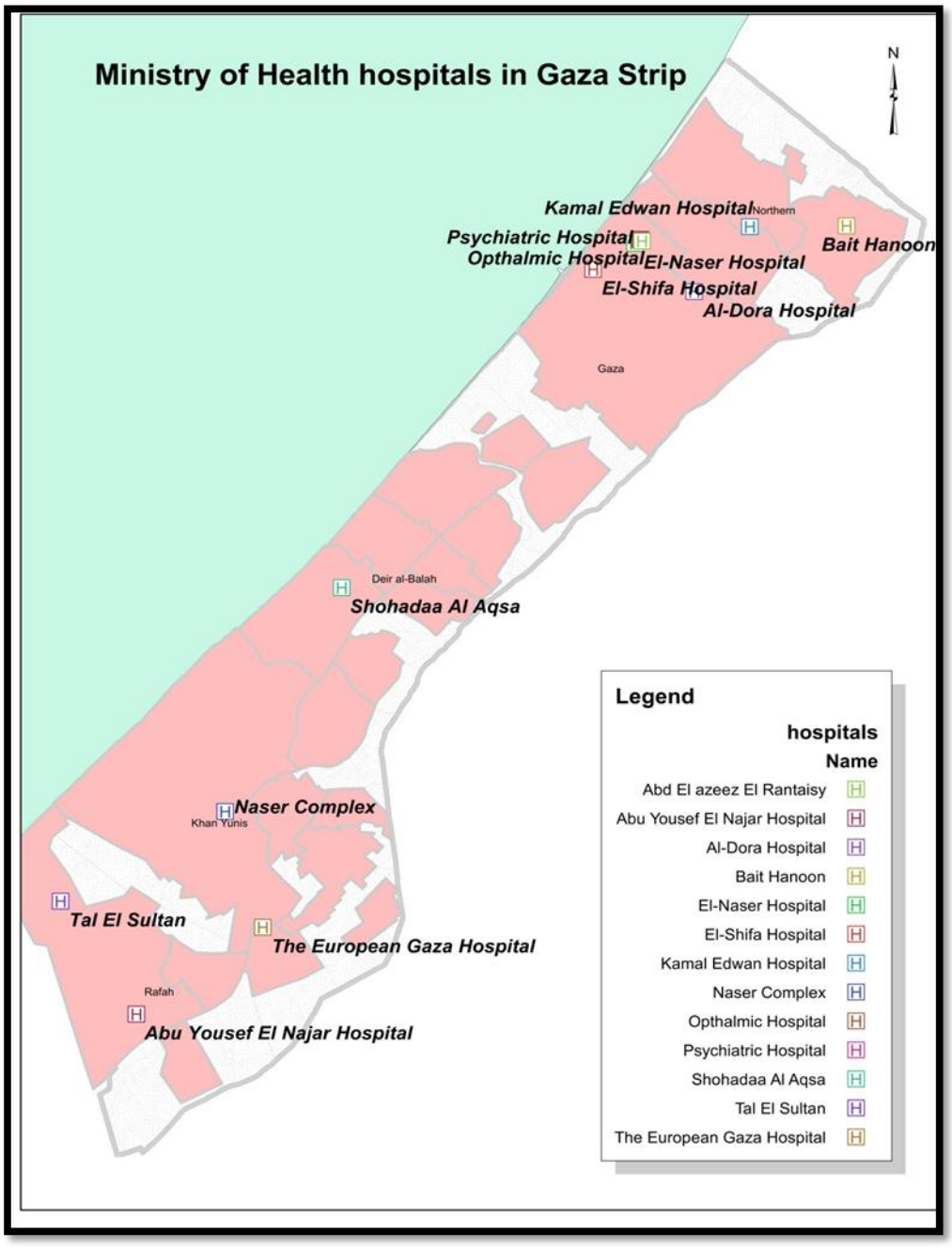


Figure 1.2 Ministry of Health Hospital`s Geographic Location

The Nongovernmental sector also demonstrates 14 hospitals which are all categorized as small hospitals according to their number of beds. Table 1.4 illustrate the NGOs hospitals, geographic location and their types

Table 1.4 Nongovernmental Hospitals Information

| No. | Hospital name | Geographic Location | Number of Beds | Type |
|---|---|---|---|---|
| 1 | Shawwa Hospital | North | 15 | Delivery (Maternity) |
| 2 | Al Awda | North | 80 | General |
| 3 | Al Karama | North | 23 | Specialized |
| 4 | Public service (الخدمة العامة) | Gaza | 26 | Specialized |
| 5 | Specialized Ophthalmic | Gaza | 2 | Specialized |
| 6 | Al Quds | Gaza | 49 | General |
| 7 | Al Ahli | Gaza | 95 | General |
| 8 | Al Wafa | Gaza | 84 | Rehabilitation |
| 9 | Patient friends | Gaza | 39 | specialized |
| 10 | Al Sahaba | Gaza | 36 | Delivery (Maternity) |
| 11 | Yafa | Middle | 24 | Specialized |
| 12 | Al Amal | Khanyonis | 108 | General |
| 13 | Dar El Salam | khanyonis | 21 | Specialized |
| 14 | Kwaiti | Rafah | 34 | Specialized |

## 1.4. General directorate of engineering and maintenance in Ministry of Health

The General Department of Engineering and maintenance provided all the necessary services to the Ministry of Health in various divisions in many areas, working to provide the right climate and logistical support to enable medical personnel and medical assistance to perform their tasks perfectly (MOH reports, 2011). The fields of services as following:

- In the field of maintenance
  - Maintenance of all buildings of the Ministry of Health (Hospitals - Clinics - health centers - general stores - central departments ..... etc.).
  - Maintenance of devices and medical equipment.
  - Maintenance of all types of furniture.
  - Maintenance of electromechanical equipment (Electricity generators - central air conditioning plants - exchanges - Elevator).
- Maintenance of infrastructure: -
  - Power networks and subsequent (generators - and other equipment)
  - Communication networks and subsequent (mechanism switchboards, telephones, faxes).
  - Water, fire and wastewater networks.
- The production of furniture and some medical equipment.
  - Furniture: Office furniture (desks - Meeting Tables - computer desks - ... etc).
  - Medical furniture (processing laboratories - Pharmacies - ambulances - etc).
  - production of medical accessories:
  - all kinds of trolleys
  - Beds ladders of one degree or two degrees.
  - Laboratory holders.
- Preparation of new projects and construction:
  - Planning and design of buildings and processing of the necessary documents for the tender (technical specifications - BoQ - General Conditions - special conditions).
  - Processing term of reference for large projects which require an external consultant for the design.

- Supervision on various projects through supervisions committees of processing the technical specifications of the devices, systems and equipment:
- Procurement

- Administrative support services.

  - General Directorate of Engineering and maintenance involved in all committees delivery (devices, systems and equipment, furniture ..... etc.).

- Planning

  - Involved the General Administration of engineering and maintenance in the field of planning for new projects intended to be established or new projects intended to be implemented.

- The field of priests.

- Issued by the General Administration of engineering and maintenance certificates priests device and systems, equipment and furniture that are downloaded from the service (MOH reports, 2011).

### 1.4.1. Maintenance staff in Gaza Strip governorates

General directorate of engineering and maintenance have got five main centers in the five governorates with total staff 316 employee for maintenance and 28 employee for the engineering department. As illustrated in Tables 1.5, 1.6 the majority of engineers are specialized in bio medical engineering which is the priority for the MOH, while there are only 7 civil engineers in the maintenance staff

Table 1.5 Maintenance staff in Gaza Strip governorates (source: MOH report, 2011)

| Governorate / Profession | North | Gaza | Middle | Khanyonis | Rafah |
|---|---|---|---|---|---|
| Head of Department | 1 | 1 | 1 | 1 | 1 |
| Administrative | - | 3 | | 5 | 3 |
| Biomedical Engineers | 3 | 16 | 3 | 3 | |
| Biomedical Technician | 1 | 14 | | | 7 |
| Civil Engineer | 1 | 1 | 1 | 1 | 3 |
| Civil Engineer assistant | - | 2 | | | 1 |
| Architecture Engineer | - | - | | | |
| Electrical engineer | 1 | 4 | 1 | 1 | 2 |

Table 1.5 Maintenance staff in Gaza Strip governorates (continued)

| Governorate / Profession | North | Gaza | Middle | Khanyonis | Rafah |
|---|---|---|---|---|---|
| Electrical Technician | 4 | - | 3 | 7 | 15 |
| Mechanical Engineer | 1 | 2 | 1 | 3 | 3 |
| Mechanical Technician | 2 | 11 | 1 | 3 | 9 |
| Electro Mechanic Technicians | | | | | 3 |
| Plumping Technician | 3 | 4 | 1 | 3 | 6 |
| HVAC Technician | 2 | 15 | 2 | 5 | 4 |
| Sterilization Technician | - | 11 | | | |
| Metal work | 2 | 12 | 2 | 2 | 4 |
| Painter | 1 | 8 | - | 1 | 2 |
| Carpenter | 2 | 12 | 2 | 4 | 4 |
| Communication Technician | - | 8 | - | | |
| Building Technician | 1 | 1 | 1 | 3 | |
| Electronics Technician | 2 | - | 2 | 2 | 3 |
| Medical Gazes Technician | | | | 1 | |
| Aluminum Technician | 1 | 4 | - | 1 | 2 |
| Office devices Technician | - | 1 | - | 1 | |
| Safety Technician | - | 1 | - | | |
| Water desalination Technician | - | 3 | 1 | 1 | |
| Worker | 1 | - | | | 3 |
| Store officer | - | - | 2 | | |
| Maintenance technician | | | | 3 | 3 |
| Total | 29 | 134 | 24 | 51 | 78 |
| Total Number | 316 | | | | |

Table 1.6 Engineering office and central workshop staff

| Work place / Profession | Engineering Office | Central workshop |
|---|---|---|
| Head of Department | **1** | **1** |
| Information system | **-** | **1** |
| Civil Engineer | **7** | **-** |
| Architecture Engineer | **2** | **-** |
| Electrical engineer | **2** | **-** |
| Mechanical Engineer | **2** | **-** |
| Civil Engineer assistant | **2** | **-** |
| Architecture Engineer assistant | **1** | **-** |
| Electrical Technician | **-** | **1** |
| Communication Technician | **-** | **3** |
| Metal work | **-** | **1** |
| Electronics Technician | **-** | **1** |
| Office devices Technician | **-** | **3** |
| Total | **17** | **11** |

Figure 1.3 shows the general directorate of engineering and maintenance hierarchical which presents the maintenance departments: medical equipment, electricity, civil and mechanic departments in hospitals and primary health care (PHC) centers

## 1.5. Research significance

### 1.5.1. Problem Statement

Ministry of health facilities especially secondary health care which is represented in hospitals plays an important role in Palestinian people`s life considering the special case of Gaza strip political situation. Siege in 2007 and war on Gaza the Israeli military assault on Gaza in 2008 affects the health sector negatively and all working teams was exhausted to be on track and to offer good service to the Palestinian people.

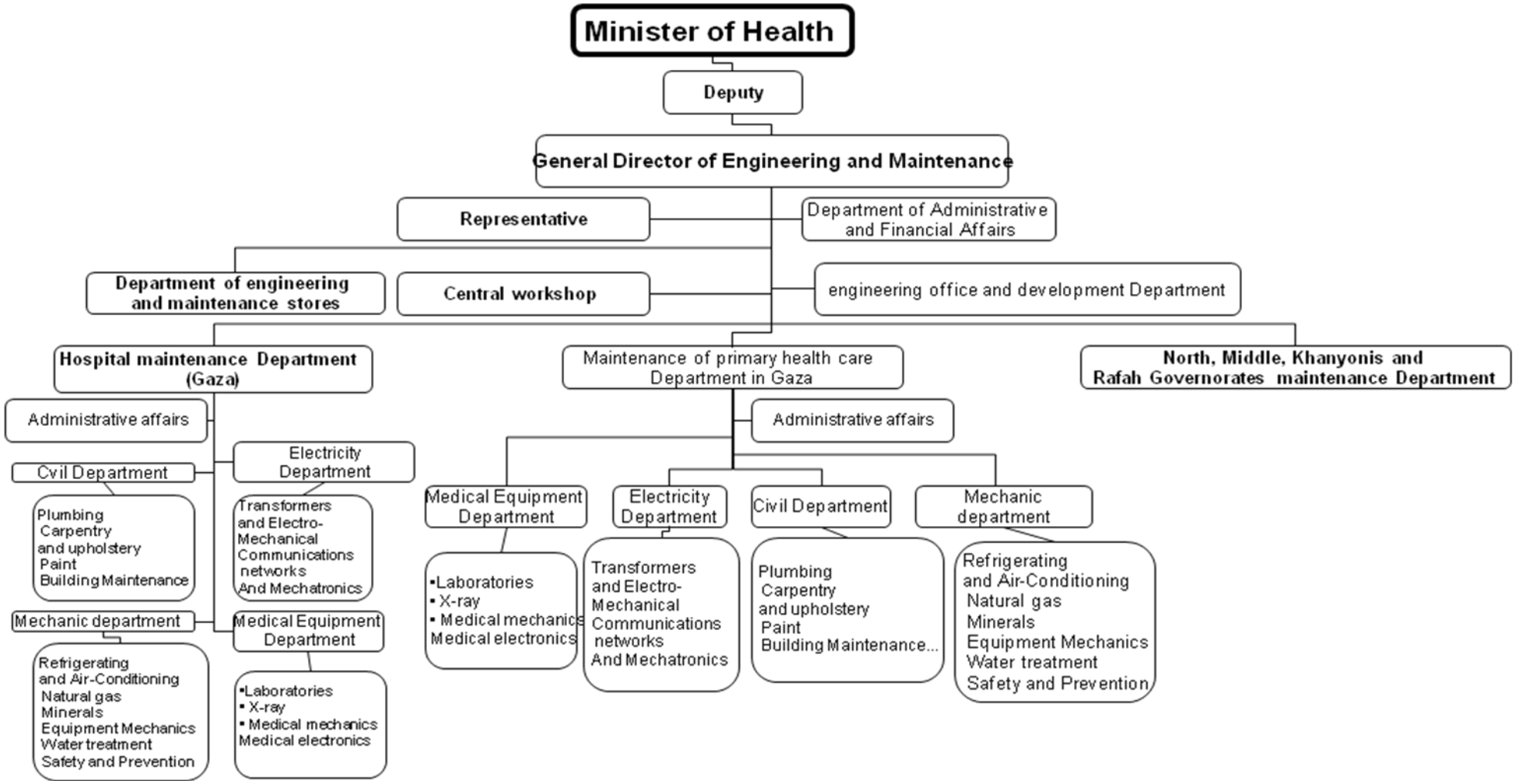


Figure 1.3 General Directorate of Engineering and maintenance in Ministry of Health (source: MOH, 2011)

Many factors are responsible for inadequate maintenance process: lack of maintenance staff, the Israeli blockade with its restrictions on the movement of goods and people, and the poor internal organization of maintenance services. Maintenance in the Gaza strip hospitals its responsibility tasked by of the Ministry of Health's (MoH general directorate of engineering and maintenance). A team of engineers and technicians based in Shifa Hospital in Gaza City the largest hospital. It also supervises and supports local maintenance units in the other hospitals in the Strip through centered departments allocated in the five governments "North, Gaza, Middle, Khan Yonis and Rafah".

Maintenance staff has lack skills, tools and equipment. There was a chronic shortage of raw materials for construction. Without cement and other building materials, a hospital cannot rehabilitate until the end of 2010. A confusion of tasks and responsibilities are not defined, job descriptions are unclear leading to a waste of effort and resources, there is no clear separation of responsibility for maintenance work in and supervision of local maintenance teams working in the hospitals (MoH, 2011).

Poor design and old age building of the hospitals in Gaza. Some of them more than 65 years like Shifa hospital and more the 50 years like Nassr Hospital in Khanyoins which results in an essential problem to building maintenance . The World Bank (2008) says that the number of MOH hospital beds increased by 53 percent from 1994-2006, which means that every bed will consume from the service of the buildings much more. So, there is necessity to find the performance indicators to evaluate how the maintenance affects the operation of the hospitals and ensure no breakdown in the health care system.

The research problem appeared from the necessary need to maintain the old age hospital buildings specially the main hospitals in Gaza strip like Shifa hospital and Nasser hospital and to conserve the new hospital building arising since 2011. Lack of scheduled maintenance activities which may lead in a huge failure in the hospital system at any time seems a big problem especially in the Gaza strip political status which makes it imperative to be ready at any moment.

## 1.6. Research hypothesis

- **$H_0$**: There is no significant existence of detailed scheduled plan for building maintenance in public hospital buildings in Gaza Strip.

  **$H_1$**: There is significant existence of detailed scheduled plan for building maintenance in public hospital buildings in Gaza Strip.

- **H0**: There is no significant coordination between maintenance staff and users of the hospital departments for the poor maintenance management of public hospital buildings in Gaza Strip.

  **H1:** There is significant coordination between maintenance staff and users of the hospital departments for the poor maintenance management of public hospital buildings in Gaza Strip.

## 1.7. Aim and objectives

### 1.7.1. Aim

To study the maintenance performance indicators in order to control the operation of maintenance in hospitals buildings in Gaza strip.

### 1.7.2. Thesis objectives

1 Assess the operational conditions carried out by the maintenance departments of public hospital buildings in Gaza strip.

2. Determine factors affecting maintenance management of public hospital buildings.

3. Measure the key performance indicators.

4. Specify the minimum requirements for the management of maintenance.

## 1.8. Research justification

Public hospital buildings are places of healing people therefore it is important to improve the operation state (physical-functional condition). This research will contribute to good maintenance performance in the public hospitals in Gaza Strip. This is because the study will attempt to find out the factors that have contributed to the present state of maintenance.

This study will assist managers of public hospitals to become aware of the current state of their building infrastructure. Also to put in a place adequate innovative measures to prevent buildings from deterioration which ultimately lead to increased cost in restoring these buildings to their original state. It will provide a model to manage maintenance which leads managers to take the decisions to carry out maintenance through the key performance indicators to control the operation of building maintenance.

Any country in the world is ranked firstly on health and education status by making the maintenance of health facility buildings one of the most priorities in the agenda of decision makers in Ministry of health will be impressive achievement.

## 1.9. Limitations

1. This study focused on Hospital buildings in Gaza Strip excluding PHC because it doesn't work 24 hours like hospitals, doesn't have all the medical equipment, requirements, no general and specialized beds, complexity of hospitals and it is considered small facilities when comparing with hospital activities.
2. Governmental hospitals in the Gaza Strip are the destination of this research because it follows the same vision, procedure and management in the work.
3. Unavailability of financial data for maintenance activities.

## 1.10 Brief methodology

### 1.10.1 Literature review:

Will focus on maintenance management and its major guidelines in health sector; review the important performance indicators and how these performance indicators can be measured and affect the maintenance management.

### 1.10.2 Data collection

- Field survey: It is the most important part of the data collection to become aware of all the situation of each hospital which can results in gathering quantitative data from the specified governmental hospitals by visiting the hospitals during maintenance works and notice performance.

- Structured Interviews: to collect the qualitative data and the performance indicators.
- Questionnaires: to collect the quantitative data and statistics
- Case studies: will be taken to compare projects done in large hospital facilities.

### 1.10.3 Data analysis

It will be based on the proper equations for the key performance indicators from the literature review and compare it with the standard values

### 1.10.4 Conclusion

Summaries and writing up includes all the data and results to obtain overall the content of the thesis

## 1.11 Thesis organization

The thesis is divided into seven chapters as follows:

**Chapter 1 Introduction**

This chapter is intended to give a brief background of research problem and assure the importance of maintenance in public hospitals buildings. As well as, it gives a description of the research importance, scope, objectives, methodology and thesis organization.

**Chapter 2 Literature Review**

This chapter includes a comprehensive literature review of hospitals buildings maintenance management, maintenance definition, types, building maintenance management, hospital building characteristics and key performance indicators for maintenance in health care facilities Also it focuses on the effects of building parameters and users and systems on the performance of maintenance and classified key performance indicators into four categories: Asset development; Organization and management; Performance management; and Maintenance efficiency

**Chapter 3 Research Methodology**

This chapter presents the main steps of the research methodology. This chapter detailed the data collection stage of field investigations of hospitals maintenance projects. How the interview`s questions were designed, the questionnaire building and the selection of the case studies.

**Chapter 4 Result and discussion**

This chapter shows the results of the questionnaire and what the maintenance status are, also the key performance measurements results of the hospitals buildings maintenance information and comparing it with the standard values.

**Chapter 5 Proposed Framework for KPI in hospitals maintenance management buildings in Gaza Strip**

This chapter gives detailed criteria for maintenance mangers in ministry of health in the Gaza strip in the field to measure the performance indicators of hospital buildings in specific way and the minimum requirements for maintenance management.

**Chapter 6 Conclusions and Recommendations**

This chapter includes concluded remarks, main conclusions and recommendations drawn from the research work.

# Chapter 2

# Literature review

## 2.1 Hospital Building maintenance management

### Introduction

The need for maintenance arises because buildings inevitably deteriorate with time due to effect of various causes. Building maintenance especially in public hospital buildings as the type that could no longer stand the test of time. Historically, in both public and the private sectors, maintenance is seen as an avoidable task which is perceived as adding little to the quality of the working environment, and expending scarce resources which could be better utilized (Afolarin, 2012). Building maintenance has consistently been treated as the 'poor relation' of the construction industry, attracting only a tacit recognition of its importance, both within the industry and amongst building owners. The pace of change in the public sector is rapid, particularly in local government and, for example, in the national health sector where notions of value and performance are driving an agenda that means building maintenance is being executed within a very different context than hitherto (Chanter and Swallow, 2006).

A hospital is not a mere building, but a complex social institution that handles the dynamics of life and death situations during the process of rendering health care. What makes a hospital a special facility is the 24 hours a day and 7 days a week facility they provide. Furthermore, a mistake in a hospital building management can cost the lives of many human beings at a time. These characteristics represent unique operating conditions and a bottom-line that involves much greater stakes than the profit-only vision of most business ventures (Adenuga, 2010). Hospital maintenance means much more than maintaining the equipment to keep the hospital building functional.

Maintenance workers have to maintain the equipment that keeps the patients alive too. That equipment is required for patient needs and is required to be maintained regularly for function ability. Hospital equipment like hospital beds and room equipment needs more precise maintenance to work properly than the building equipment does. This type of equipment that patients use when they're in the care of the hospital and that equipment is what they use to provide the care for the patients for their stay in the hospital facility (McClay, 2009).

## 2.2 Maintenance definition and types

Oxford Dictionary defined the verb maintain' as cause to continue. Maintenance, therefore, is ensuring that physical assets continue to fulfill their intended functions (Lam, 2008). Maintenance is defined as the combination of all the technical and administrative actions, including supervision, intended to retain an item, or restore it to a state in which it can perform a required function (Parida and Kumar, 2006).

Chanter and Swallow (2006) defined maintenance as a combination of any actions carried out to retain an item in, or restore it to an acceptable condition. Lind and Muyingo (2012) said that maintenance can be divided into a number of specific types. Maintenance has been classified in a number of different ways described in Figure 2.1.

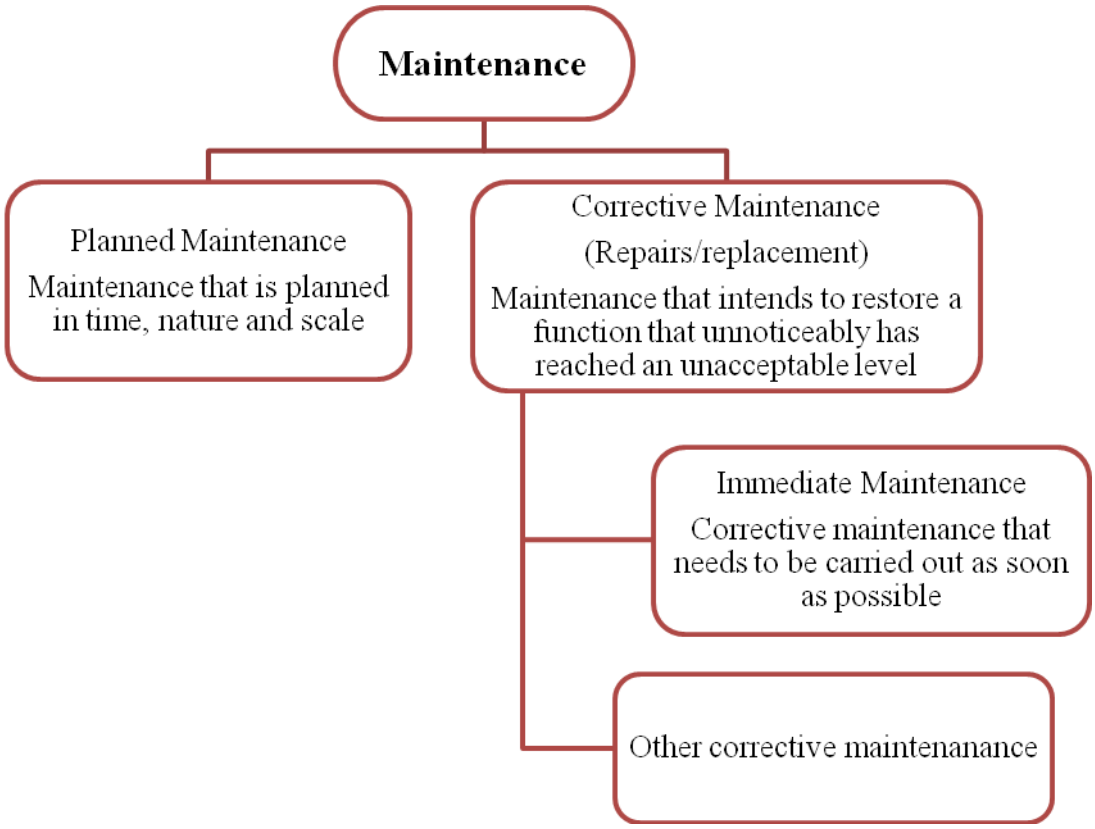


Figure 2.1 Overview of Maintenance Source: (Lind and Muyingo, 2012)

Dennis (2009) classified maintenance as follow:

- Preventive is maintenance which is carried out to prevent an item failing or wearing out by providing systematic inspection, detection and prevention of incipient failure. Preventative maintenance is usually programmed.
- Statutory maintenance is when plant such as lifts, fire systems, fume hoods and air conditioning systems are serviced and maintained in accordance with legislative requirements.
- Corrective maintenance can be defined as maintenance that is required to bring an item back to working order when it has failed or worn out.
- Backlog maintenance is maintenance that is necessary to prevent the deterioration of an asset or its function but which has not been carried out.

## 2.3 Facility management

Over the last 10-15 years, facility management (FM) in both the private and public sectors has been evolving from a discipline historically focused on individual buildings to one focused on the total performance of a portfolio of buildings in support of an organization's overall mission. FM deals with the management of built assets and incorporates controlling services necessary for successful business operations of an organization. It is concerned with the delivery of the enabling workplace environment, the optimum functional space that supports the business processes and human resources and not mainly covers the physical equipment of the building (NikMat et al, 2011). Chotipanich, (2004) mentioned FM as a key function in managing facility resources, support services and working environment to support the core business of the organization in both the long- and short-term.

Maintenance management is considered one of FM practices which involves, planning, directing, controlling and organizing maintenance activities and services to obtain maximum returns on the investment (Zawawi et al, 2011). To decide if FM is successful or not there is measurement of performance which is a fundamental principle. The measurement of performance is important because it identifies current performance gaps between current and desired performance and provides indication of progress towards closing the gaps. Carefully selected key performance indicators identify precisely where to take action to improve performance (Weber and Thomas, 2005). Factors constituting

the success criteria are commonly referred to as the key performance indicators (KPIs). The KPIs are helpful to compare the actual and estimated performance in terms of effectiveness, efficiency and quality of both workmanship and product. In short, success factors are the efforts made or strategy adopted to achieve the success on project (Toor and Ogunlana, 2010).

Maintenance managements are still being practiced in improper procedure by the maintenance managers which subsequently caused bad impacts to the facilities and the services provided. It can be seen that the managers prefer carrying out reactive maintenance works rather than proactive works and at times do not consider for clients satisfaction and also the performance of services (Zawawi et al, 2011).

Facility management emerged with the integration of three main strands of activity.
They are:
(1) Property management (real estate).
(2) Property operations and maintenance.
(3) Office administration.
They have in common the fact that they all exist to support the main activities of an organization. However, they are quite different in respect of financial impact and skill requirements (Kincaid, 1994).

## 2.3 Building maintenance management

Horner et al (1997) defined building maintenance as "work undertaken in order to keep, restore or improve every part of a building, its services and surrounds, to a currently accepted standard, and to sustain the utility and value of the building. Current building maintenance strategies, whether based on planned or unplanned maintenance, are most likely to be budget driven. This means that maintenance is not carried out according to actual need, but is dictated by financial priorities decided at the time or during the previous 12 months.

Lam et al (2010) said that in Britain, building maintenance activities have reached a level of 50% of all annual construction activities. While there has been a significant increase in refurbishment works both in the UK and in the Italian construction industries in the last 30 years, the gross value of general trades such as decoration, repair and

maintenance, and construction work at minor work locations has been increased over the past 5 years in Hong Kong.

Olajide and Afolarin (2012) showed that historically, in both public and the private sectors, the maintenance is seen as an avoidable task which is perceived as adding little to the quality of the working environment, and expending scarce resources which would be better utilized. Management of any process involves assessing performance, and maintenance management of buildings is no exception. In order for any maintenance manager to measure performance and set priorities, the organizational needs have to be considered i.e. the function and performance of buildings and their appropriate standards will be dependent on the user's perception and their primary needs.

Dhillon (2002) mentioned that since the industrial revolution, maintenance of engineering equipment in the field has been a challenge. Although impressive progress has been made in maintaining equipment in the field in an effective manner, maintenance of equipment is still a challenge due to factors such as size, cost, complexity, and competition. A maintenance department is expected to perform a wide range of functions including:

- Planning and repairing equipment/facilities to acceptable standards
- Performing preventive maintenance; more specifically.
- Developing and implementing a regularly scheduled work program for the purpose of maintaining satisfactory equipment/facility operation as well as preventing major problems
- Training maintenance staff and other concerned individuals to improve their skills and perform effectively
- Reviewing plans for new facilities, installation of new equipment, etc.
- Developing contract specifications and inspecting work performed by contractors to ensure compliance with contractual requirements
- Keeping records on equipment, services, etc.

Bin Hashem (2006) showed that the main responsibility of maintenance unit is to maintain all the facilities and infrastructures. The main job is to make sure the supporting system for activity and work process in the office is perfect. The main supporting system such as lift system, air conditional system, air intake and outlet,

electrical system, fire fighting system, plumbing and sanitary system, cleaning services, civil and structural building, landscape, safety security, pest control, telecommunication system should be working properly without any disturbance that could affect the entire office work process.

Queensland Department of Public Works (2011) states that the following conditions are not classified as maintenance:

- Improvements and upgrading to provide additional or new service capability or function
- Upgrading to meet new statutory requirements
- Major refurbishment and replacements to extend the useful life of the building
- Restoration of the entire building to operational condition after total or near total failure (e.g. resulting from natural disasters)
- Work performed under warranty or defects liability period
- Operational tasks to enable occupancy and use (e.g. cleaning, security, waste management) and supply of utilities (e.g. energy, water and telecommunications).

Silva and Falorca (2009) emphasized on the view of point of the increasing costs of new construction, the maintenance of existent buildings has become even more important. The construction industry has, for 18 years, attempted to incorporate sustainable development principles for the purpose of improving the well-being of current and future generations. The maintenance indicators are identified to complete with the performance indicators respectively which known as the performance measurement system also see table 2.1

- Functional- This aspect covers the management service delivery attributes or the service profiles that the management holds.
- Technical- Focuses mainly on the daily and scheduled maintenance services provided to the end users of the office buildings.
- Image- Is to analyze the internal and external image of the buildings (NikMat et al, 2011).

Table 2.1 The performance measurement system (NikMat et al, 2011)

| Maintenance Aspects | Performance Measurement Dimensions |
|---|---|
| Functional Management Service Delivery | Delivery Characteristics |
| | Assurance |
| | Reliability |
| | Responsiveness |
| | Relevance |
| | Timeliness |
| | Validity |
| | Maintenance Services |
| | Cleaning & Landscaping |
| Technical Maintenance Services | General Maintenance |
| | Lightings |
| | Air Conditionings |
| | Lifts/ Escalators |
| | Mechanical & Electrical |
| | Sanitary & Washing Facilities |
| | Access, Signage & Parking |
| | Safety & Security |
| Image Building Image | External Finishes |
| | Internal Finishes |

Maintenance can be done in different stages. Each stage will have different characteristics as follows:

- Planning and Design Stage: the planning and designing of the facility should be based on the identified function and be as maintenance free as possible. In this stage a lot of money can be saved with the proper plan and design. For this reason, the building manager and maintenance personnel should be consulted during the early stages of the building design.
- Construction Stage: in order to achieve minimum level of maintenance during the building life, work performed during the construction phase must be done

with the highest quality in term of workmanship. As a result, expert contractor should be selected to perform the project.

- Maintenance Stage: in this stage, maintenance is performed after the building has been constructed and occupied, periodic maintenance will be upon the function of each component in the building, which may be daily, weekly, monthly and yearly (Al-Khatam, 2003).

Bin Hashem (2006) listed some factors that influence maintenance in the design stage for building maintenance such as: deterioration, future needs and faulty of choice materials. Cooper and Jones (2008) defined the key factors that contributed to high levels of dissatisfaction of the approach to maintenance programmes poor specification of initial requirements; unclear aims and objectives and inappropriate frameworks; an inability to predict long term cost requirements; variations in levels of experience of those conducting surveys; unrealistic claims by consultants selling survey services; inappropriate or unusable data; poor links to organisational objectives; and a lack of fit of survey data. Shah Ali et al (2010) concluded the most dominant factors affecting maintenance cost were building materials, building services, building age and failure to execute maintenance at the right time. Meanwhile, it was found that two of the most influential impacts were outstanding maintenance charges and over-budget.

While Cobbinah (2010) showed another type of factors as being responsible for the poor maintenance of public buildings: The age of the buildings, lack of maintenance culture, inadequate funds and high maintenance cost, pressure on building facilities by number of users and poor construction work and maintenance work done by maintenance personnel of the institution.

## 2.4 Understanding common building defects

An important segment in the maintenance management system is the analysis of defects in the buildings. Maintenance is now recognized as tool to promote sustainability in buildings.

### 2.4.1 Building defects

Common types of building defects include: structural defects resulting in cracks or collapse; defective or faulty electrical wiring and/or lighting; defective or faulty plumbing; inadequate or faulty drainage systems; inadequate or faulty ventilation, cooling or heating systems; inadequate insulation or sound proofing; and inadequate fire protection/suppression systems. Additionally, dry rot, wood rot, mold, fungus, or termite or vermin infestation may also be the result of a building defect. An expert, such as an engineer or architect will be able to determine whether a construction problem is the result of improper design, material, or workmanship (Ahzahar et al, 2011).

Humidity is a major source of problems in buildings worldwide. Moisture can damage the building structure, the finishing and furnishing materials, besides being a direct cause of human discomfort, high indoor humidity promotes mould growth, which can have adverse health impacts on the occupants (Lourenco et al, 2006). Building maintenance prepared through an accurate program of repeated maintenance plays a major role in preventing building defects. Buildings that neglect building maintenance may fall into several defects which may lead to structural failures (Ahzahar et al, 2011). Table 2.2 outlines the summary of common defects in the buildings.

Table 2.2 Common building defects and their symptoms (Fixit institute, 2010).

| Common Defects | Symptoms/Phenomenon | Possible Causes |
|---|---|---|
| 1. Defective concrete spalling or loose plaster in ceilings | -Surface with water/rust staining, water leakage<br>-Patterned cracking<br>-Bulging, falling off of concrete patches with reinforcement exposed, often rusty<br>-Falling off of plaster/tiles | Defective concrete as a result of ageing is commonly found in old buildings. Persistent water leakage may affect the steel reinforcement. Weak concrete caused by the use of salty water in concrete mix, or overloading are also common causes in spalling |
| 2. Water seepage from external wall, window, roof, or from ceiling | -Water staining<br>-Peeling off of paint or wall paper<br>-Water dripping<br>-Growth of fungus<br>-Defective concrete, plaster or tiles<br>-Rust staining | External water seepage could be due to a variety of reasons including cracks on external wall, honey comb concrete, defective sealant at window, defective water-proofing membrane at roof, defective external water and drainage pipes, etc |
| 3. Structural cracks in Walls | -Cracks that penetrate through finishes into the concrete or bricks<br>-Long, continuous cracks across width of wall<br>-Diagonal cracks at corners of window or door<br>-Cracks with rust staining | Structural cracks may be caused by many factors, e.g. excessive movement of the building structure, unwanted ground settlement, serious overloading, and weaknesses caused by corrosion/deterioration of materials, or damage by accidents, or poor design/ construction, etc. Detailed investigation must be carried out to identify the cause(s) which must be removed or rectified before the cracks are repaired |

Table 2.2 Common building defects and their symptoms(continued)

| | | |
|---|---|---|
| 4. Structural cracks in columns and beams | -Cracks that penetrate through finishes down to the concrete or bricks<br>-Spalling | Same as item (3) above. |
| 5. Non-structural cracks (usually in plaster or other finishes with cement sand rendering as base) | -Hairline cracks.<br>-Multi-directional cracks (shrinkage cracks)<br>-Cracks between panel walls and structural elements e.g. brick wall and beams/columns | Cosmetic shrinkage cracks in plaster or other forms of finishes will affect the appearance only and do not pose any safety concern. They are small hairline cracks developed within the finishes layer not penetrating down to the reinforced concrete structure |
| 6. Defective external wall finishes/mosaic tiles/ceramic tiles/stone cladding/curtain wall | -Debonding of finishes/tiles from wall structure resulting in "hollow sound" when tapped with a hammer<br>-Cracking of wall surfaces<br>-Bulging with hollow base<br>-Falling off<br>-Cracks -Loosening of parts | The defects could be due to ageing, structural movements, defective workmanship during installation, thermal movement, defective or missing expansion joints, damage by external factors (e.g. falling objects during typhoon), ingress of water into the gap between the finishes or tiles and the structure, etc. |

## 2.5 Hospital building characteristics

Hospital buildings can be described as sophisticated public areas due to their functional organizations complexity and architectural configuration (Graip, 2011). The increase in sophistication and complexity of medical services within the health service is reflected in the sophistication and complexity of buildings, their finishes, fittings, contents and services (Al-Zubaidi, 1997).

According to Ching et al, (2011) there are factors such as an increase in patient numbers, demands for more hospital beds, and expansion of hospital divisions, all make the original hospital configuration inadequate, and additions or alterations must be added to the building in order to meet both current and future needs. Because hospitals cannot suspend all medical practices or reject patients, the reconstruction of hospital building must coincide with its normal hospital hours. According to Kennett (2006) hospitals are constantly renovating, whether they are just adding electrical outlets or communications cables, or engaging in more complex projects that involve moving functions and building additions to the existing structures. This kind of change is a result of many factors: changing personnel, new technologies, and competitive pressure. Some changes, however, may affect the use of spaces or facilities originally planned and built for emergency operations. For instance, renovation may inadvertently upset bracing for piping and communications conduits, making them more vulnerable to hazards like earthquakes or high winds.

MoyJr (1995) mentioned that to ensure that all operating and emergency backup systems are functioning properly; the health facility managers must conduct periodic testing of equipment and procedures, as required by regulatory agencies. One of the reasons that health-care organizations undergo such rigorous inspections is the high cost of liability (malpractice) insurance required to protect the assets of a facility, as well as the staff. Maintaining high standards helps to minimize risk potentials, such as loss of life or injury caused by building or equipment malfunction during normal or emergency situations. The modern hospital environment in any society is filled with many dangerous materials and equipment, for example:

• Gases (ethylene oxide used for sterilization of instruments, anaesthetics, natural gas).

• Needles and sharp instruments;

• Biohazards/infectious disease contaminants (laboratory specimens, body fluids, etc.);
• Radioactive materials (isotopes, X-rays, etc.);
• Chemicals (disinfectants, cleaning solutions, pharmaceuticals, pesticides, etc.);
• Electromechanical equipment (monitors, electric beds, electricity, etc.);
• Laboratory equipment (laser, tissue and other specimens) (MoyJr, 1995).

### 2.6.1 Operating rooms (ORs)

Operating room is the hospitals largest cost and revenue department, it has a major impact on the performance of the hospital as a whole. Health managers have to anticipate the increasing demand for surgical services (Cardon et al, 2010). Balaras et al (2006) believed that operating theatre design has responded to changes in surgical needs and practice. The size and number of ORs in a hospital depends on the total size of the facility, the number of beds and the type of medical treatment. Usually, the number of ORs in hospitals is about 2.5% of the total number of hospital beds, although it strongly depends on the hospital functions.

For surgeons and medical staff, and of course, the patients, heating, ventilating and air-conditioning (HVAC) installations control indoor air quality and aseptic conditions, and secure healthy, safe and suitable indoor thermal (i.e. temperature, humidity, air quality and airflow) are vital demand conditions. The air in an OR must be aseptic, at a reasonably constant temperature and humidity and have relatively low velocity in order to avoid drafts and swirls that promote the recirculation of microbes and may disrupt the procedures during an operation (Balaras et al, 2006).

Reymondon et al (2008) showed that within health facilities, any medical supply that is foreseen to be in contact with a patient must be sterilized. Single use materials are already sterilized when purchased, while at least partly because initial purchase of surgical instruments is very expensive reusable devices needed for surgical operations are generally sterilized in centralized sterilization facilities. The sterilization of reusable medical device (RMD) is a high-quality process, which ensures that sterilized devices can be safely used during any subsequent surgical case.

## 2.6.2 Ventilation

Yam et al (2011) emphasized on the idea that since the development of effective ventilation systems, most hospitals were designed as "thick" buildings, where many areas do not have natural light and depend on mechanical ventilation to be usable .The main sources of air supply for most hospitals are natural ventilation and installed air-handling units (AHU) that draw air from outside the hospital building.

Chow and Yang (2003) believed that the provision of ventilation system in a hospital operating room is crucial for human comfort and protecting the patient and surgical staff against hazardous emissions. In order to reduce microbial exposure, the use of laminar flow ventilation is the engineering practice in those operating rooms designed for deep wound surgery. The supply air diffuser is located at the ceiling directly above the operation area, with the low-level exhaust outlets at the room periphery. This arrangement develops a down flow of clean air through the breathing and working zones, then to the floor level for exhaust.

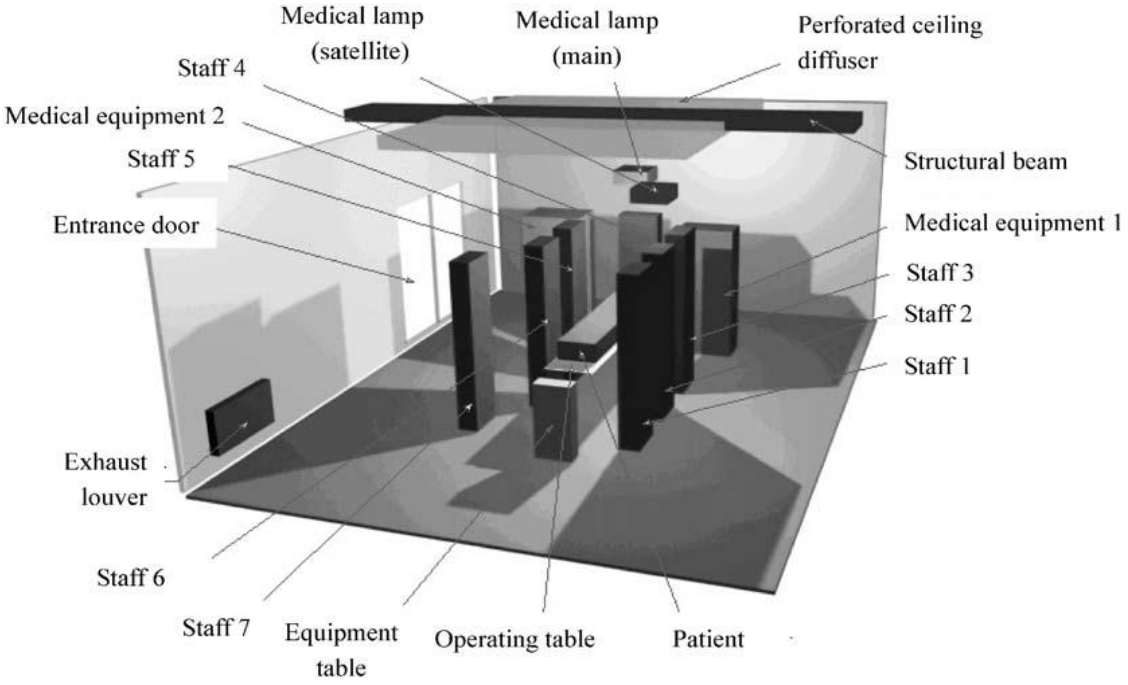


Figure 2.2 Operating room arrangements Source (Chow and Yang, 2003)

## 2.6.3 Rooms planning

Arrangement of rooms was considered on particular, decisions were made on the number of bays, single rooms, bed spacing, utilities and toilets. Clinical user groups were formed early in 1998 to ensure that all interests were included. Some clinicians

regularly attended and contributed to these meetings. Others did not and as a result may not now have the environment they wished for (Wilson and Ridgway, 2006).

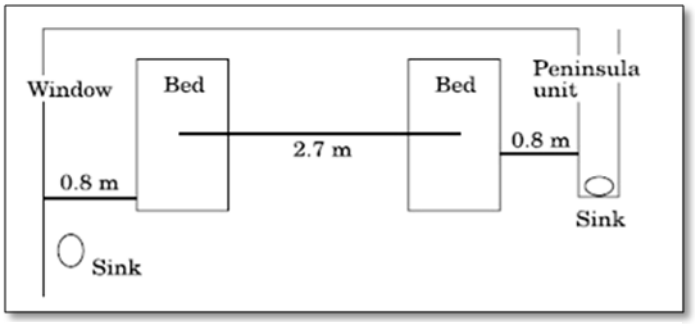


Figure 2.3 Typical Bed Arrangement Source:
(Wilson and Ridgway, 2006)

### 2.6.4 Hospital floor

Department of veterans (2008) recommend that hospital floors must perform criteria such as durability, slip resistance, hygiene and maintenance, these characteristics are vitally important to suit different healthcare environments. Floors in exam rooms, treatment rooms, and most other spaces should be vinyl composition tile (VCT) with a 4 inch high resilient base. Floors in toilet rooms should be ceramic tile with a ceramic tile base. Floors in radiographic rooms require a 4 inch deep depression to facilitate installation of the floor trench duct system. Floors in interventional radiology rooms or radiographic rooms intended to support image- guided or minimally-invasive procedures should be welded seam sheet flooring with an integral base.

### 2.6.5 Medical equipment

Medical device is a major component of today's healthcare systems as it is utilized for patient diagnosis and treatment. Patient equipment must be regularly maintained to have highly functioning equipment for quality care. Clinical engineers are faced with a variety of daily tasks including equipment recalls, preventive maintenance and corrective maintenance. The manual process of locating equipment throughout entire hospital campuses is labor intensive. Often, when the equipment is finally located, the clinical engineer is not able to collect the piece of equipment because it is in use or is scheduled for use (Al-Bashir et al, 2012).

Cruz and Rincon (2012) considered that maintenance should be outsourced, when a health care institution lacks the technical skills or specialized assets needed for the maintenance of its medical technology. Tavakoli et al (2007) said that medical equipment should be maintained at a higher safety level than other types of equipment for the following reasons:

- They may be used on patients who are not able to respond to hazardous conditions or pain.
- Actual electrical connection may exist between equipment and patient; and
- Certain types of medical equipment function as life support and their failure could result in the patient's death.

### 2.6.5.1 Sterilization

Sterilization is the elimination of all viable microorganisms. Sterility Assurance Level (SAL) refers to the complete sterility of an item: an SAL of 106 represents a one in a million chance of an organism surviving on an item and is considered 'sterile'. Steam sterilization (autoclave) is the most dependable and considered the method of choice in healthcare. It is rapid, nontoxic, and inexpensive and has high lethality. It is unsuitable for heat labile and lensed instruments. Items should be cleaned to reduce bio-burden and packaged before loading into autoclave (Veerabadran and Parkinson 2010).

The current trend in healthcare leads to group surgical suite and healthcare facilities in order to share equipments and transversal resources. Following this trend, the set of RMD increases which need centralized sterilization (Reymondon et al, 2008). Veerabadran and Parkinson (2010) introduced the basic principle is exposure of an item to dry saturated steam at the required temperature for the specified time. Dry hot air is a relatively ineffective method. Sterilization occurs by automated exposure of items to dry heat in a hot air oven.

### 2.6.5.2 Radiation

Radiation is a general term used to describe a bundle of energy in the form of electromagnetic waves. Radio waves, microwaves, ultraviolet (UV), x rays, gamma rays, and visible light are all forms of electromagnetic or EM waves X-ray machines and radiation emitting sources are used in hospitals for the diagnosis and treatment of diseases(Bank and Kelsey,1995). Radiology Imaging Services may be organized as one

central department which serves emergency, outpatients, and inpatients, or as separate facilities for inpatients and outpatients. Several factors should be considered when determining the location of Radiology Services within a facility. This service should be strategically located to maximize efficiency in usage. As technology is constantly changing and new methods of Imaging Services are being developed, consideration should also be given to the high probability that the area will require renovation, expansion and / or equipment replacement in the future (Department of veterans, 2008).

### 2.6.5.3 Shielding in radiation rooms:

Material that absorbs the radiation is a shield. The thicker the shielding, the more the radiation exposure decreases. Some materials are better than others. Lead and concrete are the most commonly used materials for shielding x rays and gamma rays. They are very effective in stopping or blocking the radiation beam (Bank and Kelsey, 1995).

### 2.6.5.4 Medical gazes

Within hospitals, many areas will have pipeline-supplied medical gases. Most frequently this is oxygen; however, in operating theatres this will include medical air and nitrous oxide and in some delivery suites Entonox (50% oxygen, 50% nitrous oxide mix). Piped medical gases are distributed through the hospital from a central source. Increasing hospital demands for oxygen have led to the use of cryogenic liquid systems for both main and reserve supplies. One liter of liquid oxygen produces 842 L of oxygen gas at room temperature. Hospitals should hold a minimum of 14 day supply of oxygen but this should be increased if there is delivery or logistical problems (Highley, 2009).

## 2.7 Key performance indicators for building maintenance in health care facilities

### 2.7.1 Introduction

The performance measurement revolution started in the late 1970s and early 1980s with the dissatisfaction of traditional backward looking accounting systems. Although the concepts of performance measurement are developed to improve the performance of a business, it can sometimes mislead management (Nudurupati et al, 2007). Measuring and analyzing organizational performance plays an important role in turning

organizational goals to reality. The first step towards an improvement is to make explicit the available knowledge on performance indicators and how they are related to use this knowledge in a modern framework for organization modeling. It is necessary to formalize the concept of a performance indicator together with its characteristics, relationships to other performance indicators and relations to other formalized concepts such as goals, processes and roles (Popova and Sharpanskykh, 2010).

The recent decades have witnessed a maturing of concern and interest in building performance that is increasingly evidenced in building design. Building performance is complex, since different criteria in the building sector have differing interests and requirements. One of the complexity reasons the lack of consensus on what constitutes excellence in building assessment performance, covering the overlapping dimensions of social, economic, environment and technological factors (Alwaer and Croome, 2010).

### 2.7.2 Key performance indicators definition

Key performance indicators (KPIs) are commonly used by an organization to evaluate its success or the success of a particular activity in which it is engaged. Sometimes success is defined in terms of making progress toward strategic goals, but often success is simply the repeated achievement of some level of operational goal (for example, zero defects, 10/10 customer satisfaction, etc.). Accordingly, choosing the right KPIs is reliant upon having a good understanding of what is important to the organization. A very common way for choosing KPIs is to apply a management framework such as the balanced scorecard (Key performance indicators, 2012). Jardali, et al. (2011) mentioned that one such increasingly employed method for measuring and reporting health system performance is the balanced scorecard (BSC). The BSC tracks indicators across different perspectives, which provides a balanced view of performance and guides strategic decisions at both the hospital and health system levels.

Luu et al (2008) define performance measurement as the heart of ceaseless improvement. Performance management aims at offering managers and members of staff of all ranks the ability to develop the direction, traction and speed of their organization. Toor and Ogunlana (2010) considered that factors constituting the success criteria are commonly referred to as the key performance indicators or KPIs. KPIs are

helpful to compare the actual and estimated performance in terms of effectiveness, efficiency and quality of both workmanship and product. In short, success factors are the efforts made or strategy adopted to achieve the success on project. Alwaer and Croome (2010) defined an indicator system should provide a measure of current performance, a clear statement of what might be achieved in terms of future performance targets and a yardstick for measurement of progress along the way.

Ahmad and Dhafr (2002) suggested that KPIs are values or figures that can be compared. KPIs can be compared with the base of the internal or external target performance indicators, and the values of KPIs are involved in information collection, calculation, or other processes. Giff and Crompvoets (2008) defined performance indicator (PI) as a metric that measures the degree to which key functions (objectives) of an organization are being achieved. PIs are usually possess the general characteristic of any information along with the organization`s own unique characteristics. A quantitative PI comprises a numeric value that provides magnitude (how much), and a unit of measure that gives the numeric value meaning. In addition, a quantitative PI can be a single dimensional unit (e.g., meters or dollars) or it can be a ratio.

Tsang (1998) classified the commonly measures of maintenance performance into three categories on the basis of their focus:

(1) Measures of equipment performance – e.g. availability, reliability, overall equipment effectiveness;

(2) Measures of cost performance – e.g. labour and material costs;

(3)Measures of process performance – e.g. ratio of planned and unplanned work, schedule compliance.

In most cases, these measures are tracked because:

• The organization has always used them;

• Other organizations are using them; or

• The required data are easy to collect

Building maintenance practitioners believe quality, safety, time, cost, functionality, and environmental friendliness can be considered as KPIs for building maintenance activities. A single index can also be computed from the maintenance achievement equation to apply different weightings to the respective KPI with different significance

such that the performance of building maintenance managements can be compared (Yahya and Ibrahim, 2012).

## 2.8 Key performance indicators in construction industry

Applying performance measurement in the construction industry it can be seen as an action case investigating manufacturing methodologies (Nudurupati, 2007). Whereas, KPIs are the compilations of data measures (either by quantitative or qualitative data) used to access the performance of the construction operation. Despite extensive research, there is no general agreement on a set of KPIs for construction projects to-date. Therefore, there is need for identifying a set of common indicators to be used by construction executive and project managers in measuring construction performance at the project level. Performance measurement in construction project has been dominated by the conventional measures of time, cost, and quality (Toor and Ogunlana, 2010).

Kagioglou et al (2001) considered the construction industry's core business is undertaking projects in generating new buildings or refurbishing existing ones for a variety of clients. Performance measurement in construction can be approached in two ways: a) in relation to the product as a facility, b) in relation to the creation of the product. Takim et al (2003) in the manufacturing and construction industries, performance measurement is used as a systematic way of judging project performance by evaluating the inputs, outputs and the final project outcomes. Kagioglou et al (2001) listed that in UK construction industry the measurement of project performances, based on 10 identified parameters. These consist of seven project performance indicators:

1. Construction cost;
2. Construction time
3. Cost predictability (design and construction);
4. Time predictability (design and construction);
5. Defects;
6. Client satisfaction with the product
7. Client satisfaction with the service;

and three company performance indicators namely:

8. Safety;
9. Profitability ;
10. Productivity.

Recently the UK best practice programme (bprc) has launched the 'key performance indicators' (KPIs) for construction (bprc 1999). These KPIs give information on the range of performance being achieved on all construction activity and they comprise of:

1. Client satisfaction – product
2. Client satisfaction – service
3. Defects
4. Predictability – cost
5. Predictability – time
6. Profitability
7. Productivity
8. Safety
9. Construction cost
10. Construction time (Kagioglou et al, 2001).

Alexander, (2011) defined the term building performance can interpreted in different ways, how the building performs in itself, how it performance against identified requirements, or how it is perceived by users. In a broader sense building performance can be used to describe the impact of the building on the environment and upon community development. As concepts of building performance have evolved, theoretical frameworks have developed to guide practical and applied research on buildings-in-use.it can be considered that the building blocks of a theory of feedback from buildings-in-use as: building performance how specific design and construction decisions have affected mechanical and electrical performance, envelope (energy) performance and the like human performance how users behavior is enhanced and supported by the spaces designed for it; and social value ultimately, a building, like any other product of concerted human social action, should be assessed in terms of the improvement it brings to users and to society at large.

## 2.9 Key performance indicators in hospital building maintenance

Lavy and Shohet (2010) proposed an integrated healthcare facility management model (IHFMM) provides insight into the assessment of parameters that affect maintenance, performance, and risk in healthcare facilities, occupancy, age, and performance of

buildings. The proposed model consists of three main interfaces: Input Interface, Reasoning Evaluator and Predictor, and Output Interface see figure 2.4

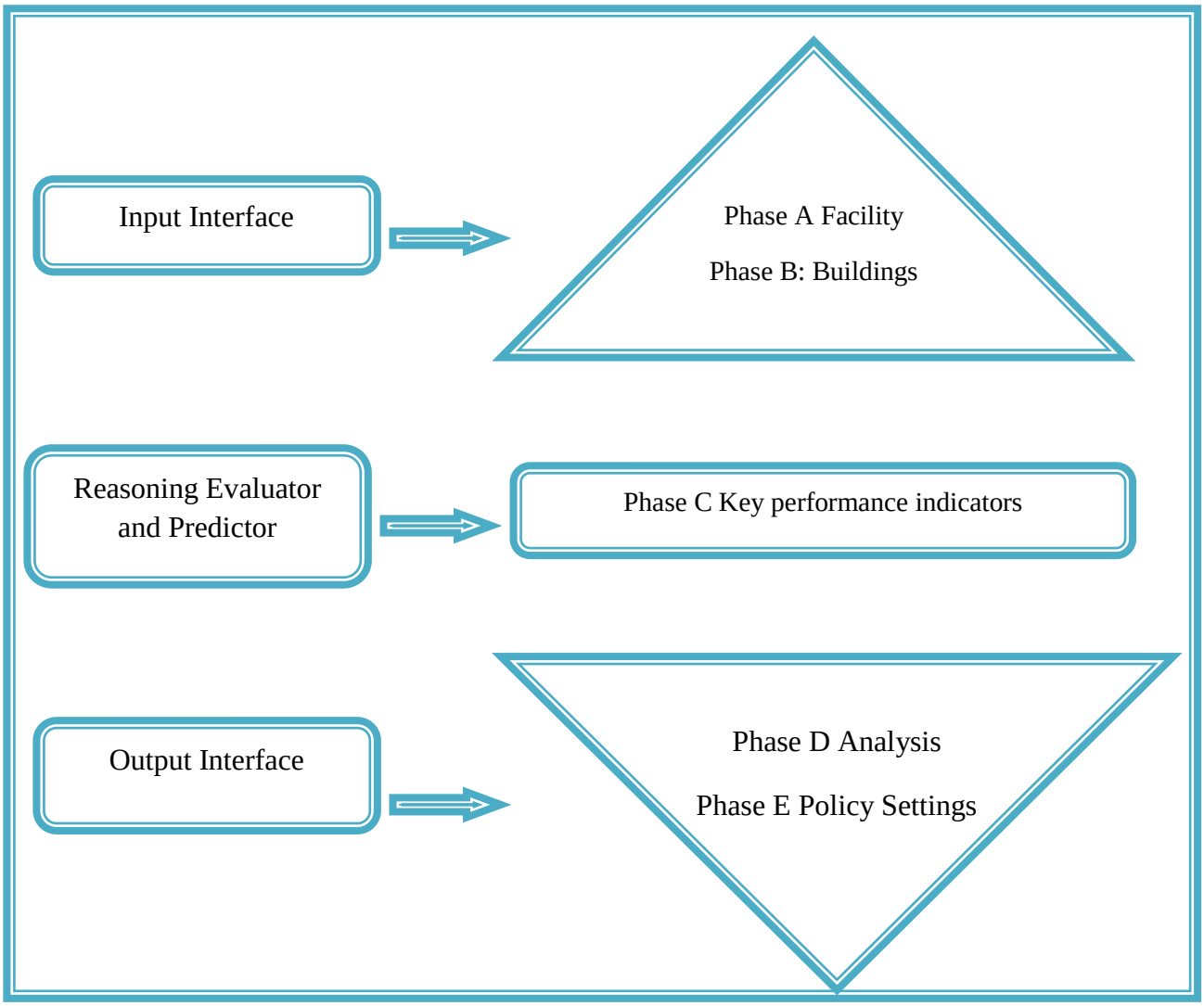


Figure 2.4 Integrated healthcare facility management model (source: Lavy, 2006)

Shohet et al, (2003), Lavy (2006), Pati, et al (2009) and Shohet (2003) also listed currently existing performance indicators as follows:

1. Building performance indicator (BPI)
    a. This parameter enables the evaluation of the overall state of the building, according to the performance of its components and systems. The indicator is defined by a value, between 0 and 100, that expresses the building's state, including the performance of its various systems.
2. Maintenance efficiency indicator (MEI)

This indicator examines the maintenance inputs, as calculated based on the annual maintenance expenditure (AME), with respect to the physical and performance state of the building as expressed by the building performance indicator (BPI).

3. Manpower sources diagram (MSD): a ratio of in-house and outsourcing expenditures
4. Managerial span of control (MSC): a ratio of a manager and subordinated personnel
5. Business availability in %: an available floor area over an entire floor area over year
6. Manpower utilization index (MUI) in %: a ratio of man-hours spent on maintenance and total available man-hours
7. Preventive maintenance ratio (PMR) in %: a ratio of man-hours spent on preventive maintenance and total maintenance.
8. Average time to repair (ATTR): unit repairing time in hour
9. Maintenance productivity (under development)
10. Urgent repair request indicator (URI) and general repair request indicator

Urgent Repair Request Index (URI) is defined as: $URI = \frac{UR}{UR + GR}$

Where UR is the number of urgent repair requests arising from guests and in-house staff, and GR is the number of general requests for repair of the building facilities. It should be noted that if the engineering staff are able to carry out maintenance on a continuous basis to keep the equipment and systems in good order, the amount of urgent repairs would be reduced. A high value of URI means that the engineering staffs are heavily engaged in urgent repairs, being distracted from carrying out normal corrective and preventive works, and in the long term the building will suffer from loss of business and prestige (Park and Augenbro, 2003).

## 2.10 Previous related research

### 2.10.1 Palestine (Gaza Strip)

World health organization (WHO), United Nations development programme (UNDP) and United Nations educational scientific and cultural organization (UNSCO) cooperated with ministry of health to (MOH) in 2010 to undertake an

assessment of the infrastructure of the public MoH health facilities in Gaza. The purpose of this cooperation was:

- To provide an overview of the overall condition of the estate, in terms of the number, size and efficiency of the hospitals.
- To identify the most urgent priorities for investment and rehabilitation.

The assessment was carried out by a joint WHO/UNDP team, comprising engineers and health experts, in conjunction with MoH engineers and managers in Gaza and with support also from UNSCO. The team developed a detailed survey and assessment criteria and visited all the hospitals and PHCs to carry out the assessment.

They found that most of the hospital buildings were in a reasonable physical condition, better than might be expected after almost 5 years of siege. This is partly because significant rehabilitation work has been undertaken in the past few years funded by Arab donors (with materials imported through the tunnels).

- The physical condition of 8 of the 13 hospitals was rated " good"
- The condition of just 4 hospitals was rated poor, as an average score
- In 5 hospitals, however, some buildings (or parts of them) need replacing
- The most frequent problems identified were the absence or very poor condition of fire protection system (in 11 hospitals) and the fact that elevators were not available or not functioning (in 5 hospitals)
- Most hospitals need substantial refurbishment of the interior to improve their appearance.

The hospital utilities were mostly in a much worse state than the buildings

- The main problems are with solid waste systems (in all 13 hospitals) and warehousing and storage (in 10 hospitals).
- The HVAC, supplementary pumping system and water tanks were all in a poor condition in the majority of hospitals

Murad (2010) conducted a study to evaluate the effectiveness of the medical equipment management cycle that currently in use in Governmental Health

Facilities in Gaza Strip, and to suggest simple methods for the improvement of equipment management.

The study was conducted in all governmental health facilities in Gaza Strip which are supplied periodically with medical equipment. The checklist consisted of: 1. Status of imaging equipment, 2. Reasons for non functioning equipment, 3. Number and type of donated equipment. 4. Inventory card and the documentations of the equipment, 5.Preventive maintenance. The check list was done in the x-ray departments in all major hospitals because x-ray equipments are the most commonly used equipments and can be found at all hospitals regardless of the hospital size. The study showed that 92.6% of the health managers, doctors, and nurses didn't receive any training course in the last three years. Politically and administratively hardly any attention is paid to training. More than 54.4% of the participants reported that there are no adequate spaces and suitable stores for keeping and using medical equipment, and 61.1%reported that there is no preventive maintenance system in their department; 83.7% of them reported that most of equipment that were malfunctioning were due to lack of spare parts; and 54.8% were unsatisfied about the status of medical equipment management in their departments.

### 2.10.2 Occupied Palestinian Territories (Israel)

Shohet (2003) developed a model for the overall maintenance management of hospitalization buildings based on indicators of performance, budgeting and resource allocation. The basis for the development of the model was a field survey of 17 major public hospitals in Occupied Palestinian Territories (Israel)and a statistical analysis of the survey data. A coefficient of maintenance and Performance was as follows:

- The effect of various labor sources mixes (outsourcing vs. in-house provision) on the annual maintenance expenditures of hospital buildings;
- The effect of the occupancy level of hospitalization wards on their maintenance costs;
- And the effect of the buildings age on its annual maintenance costs.

The Building Performance Indicator (BPI) analysis resulted score 66.1 indicating that hospital was in condition of deterioration, the Maintenance Efficiency Indicator (MEI) equals 0.45 which in the middle range (0.37 - 0.52).

Lavy and Shohet (2004) have developed quantitative management indicators for the examination of hospital building performance and budgeting of their maintenance activities. With this in mind, four indicators were developed:
(1) The Building Performance Indicator (BPI) (2) the Manpower Sources Diagram (MSD) (3) the Maintenance Efficiency Indicator (MEI) and (4) the Managerial Span of Control (MSC). In summary an analysis of the building age showed that, over the course of time, maintenance requirements are characterized by a great deal of fluctuation (between +33 per cent to -45 per cent of the multi-year average value). Therefore, there is a need to develop a managerial-quantitative model to address this issue. Furthermore it was found that occupancy exerts a considerable effect on the deterioration of the building and its systems. This effect ranges between +22 per cent at very high occupancy levels and -5 per cent at low occupancy levels. Manpower sources exerted the least influence and their effect was not conclusive.

Lavy (2006) conducted to identify the effect of defined parameters, such as the actual age of a building, level of occupancy, and maintenance expenditure on the performance of facilities. The conceptual framework developed in this research proposes a comprehensive model that deals with the following five core topics of Healthcare facility management:

1. Maintenance Performance
2. Risk
3. Energy and Operations
4. Business Management
5. Development.

This research focused on the maintenance, performance and risk aspects of Healthcare FM. Two case studies were carried out in two different acute-care hospitals in Israel, in which the model was evaluated and validated, and as a result, improved and refined. The results obtained in these hospitals in a 2004 field survey were compared with those from a 2001 field survey.

### 2.10.3 Saudi Arabia

Ikhwan and Burney, (1999) developed research in order to assess the existing maintenance practices; a survey was carried out in twenty hospitals of Jeddah and Taif cities. These hospitals were equally divided between the government and private

sectors. On a combined basis; the results present an encouraging picture of the maintenance practices. The proportion of maintenance staff is high, the workers are provided training facilities, they have vocational qualifications, the system of working includes both predictive maintenance and breakdown maintenance and is fairly well developed, the facilities are mostly provided, various maintenance reports are prepared, and Maintenance Planning and Control Offices are there in most of the hospitals. The more serious problems faced are regarding non availability of spares, shortages of technical manpower and lack of funds.

### 2.10.4 Malaysia

A research examined the process of building maintenance and management in Malaysia with the aim of identifying factors causing poor maintenance in various types of buildings, and delivering a new improved process. The results appeared that maintenance work in Malaysia is described as a service industry. Most buildings face similar problems in terms of breakdowns and other weaknesses that have an effect on the quality of the system. Lighting, HVAC, telecommunications and sanitation need the most maintenance attention. Scheduling and prevention planning would be good solutions to improve this situation (Zawawi et al, 2010).

Another study conducted by Yahya and Ibrahim (2012) aimed to develop a maintenance achievement index (MAI) to benchmark the performance of building maintenance from a number of key performance indicators (KPIs). Eleven high rise office buildings were investigated through randomly selection in Klang Valley, Malaysia. The research collected 110 respondents from in-house building maintenance personnel and outsourced consultant as well as contractors with managing and operating building maintenance activities experience of high rise commercial buildings through unstructured interviews. In addition, a maintenance achievement equation was formulated from the primary components analysis to generate a multiple score so as to show the level of achievement of building maintenance management. The findings of study had shown that building maintenance practitioners believe quality, safety, time, cost, functionality, and environmental friendliness can be considered as KPIs for building maintenance activities (Yahya and Ibrahim, 2012).

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This paper presents the results of an audit assessment conducted on the maintenance organization undertaking facilities maintenance management in a public hospital. The goal of this research was therefore to identify the maturity level of the maintenance organization in a specific hospital with regard to the effectiveness of their management of facility engineering maintenance (FEM) services. Five elements were assessed based on three respondent groups, namely: hospital, contractor, and consultant. Results on the contractor's performance indicated many areas of weakness with regard to the assessment elements, namely: policies; plans and procedures; training and orientation; and service performance. The effectiveness rating obtained from the radar diagram revealed that the maintenance organisation in the case study hospital is operating within a "maturing" stage. The result suggests that the maintenance organisation in the case study hospital has still not realized the importance and benefits of effective maintenance management. It was apparent from the research findings that the maintenance organization had not made much effort to accomplish their roles and responsibilities towards successful implementation of FEM services (Ali, and Mohamad, 2009).

NikMat et al (2011) conducted a study that proposed a Performance Measurement System (PMS) for the enhancement of FM specifically focusing on the maintenance delivery aspect. The PMS, which encompasses three important aspects of maintenance namely functional, technical and image, developed with respective PM dimensions and tested in five chosen office buildings in Malaysia.

This study also suggested a positive correlation between the performance of maintenance management and the maintenance management system applied. In general results, there is a minor discrepancy of priorities order between end users and maintenance managers. It is strongly believed that this is due to different dimensions of importance viewed by these focus groups based on their experience as users and providers. The findings also suggest that the common maintenance management systems applied for office building comprises of three major aspects namely Functional, Technical and Image.

While Shah Ali et al (2010) their study was to determine and identify the factors contributing to rising maintenance costs. The literature review identified 19 variables of factors affecting housing maintenance cost. It was found that five of the most influential

variables were expectation of tenants, building materials, building services, building age and failure to execute maintenance at the right time. It was also found that two of the most dominant impacts were outstanding maintenance charges and over-budgeting.

### 2.10.5 Nigeria

A study was held in South-West, Nigeria covered 46 public hospitals representing to examine the labour composition for maintenance works in the public hospital buildings in South-West, Nigeria, and in the process identified if there are any significant differences in the execution of maintenance works using outsourcing and in-house labour. 40% of the total number of existing public hospitals based on stratified random sampling technique. Data collected were analyzed using mean item score, and spear rank correlation coefficient. Findings of the study revealed that the staff strength of the maintenance departments is inadequate and they are inexperience on hospital maintenance management. Majority of the users of public hospital buildings do not have access to any formal training on effective use of hospital facilities. The skills considered necessary for an effective maintenance manager in executing maintenance operations in public hospitals are also revealed. The cause of low motivation in executing the desired maintenance programs was also established (Afolarin, 2012).

### 2.10.6 Ghana

A study from Ghana was designed to assess the current condition of public buildings, identify the underlying principal causes of poor maintenance of public buildings, analyse the maintenance policy and practice and capacity of the maintenance and estate departments of public institutions and make suggestions and recommendations towards the adoption of effective maintenance policy and innovations that would address the building maintenance problem in public institutions.

The study has established that housing maintenance is a real problem among public institutions in Ghana, with about 83 percent of all residential buildings of public institutions surveyed having maintenance problems. The maintenance problems the study observed have been influenced by the age of the buildings, lack or absence of a national maintenance policy, inadequate funds and high cost of maintenance, low capacity of maintenance staff, apathy and lack of patriotism on the part of occupants, pressure on buildings due to the number of users among others (Cobbinah, 2010). Table 2.3 summarized all related previous studies.

Table 2.3 Summary of related previous studies

| Research Location | Main Objective | Year | Main Findings | References |
|---|---|---|---|---|
| **Palestinian territories Gaza Strip** | -To provide an overview of the overall condition of the estate, in terms of the number, size and efficiency of the hospitals | 2010 | ▪ The physical condition of 8 of the 13 hospitals was rated " good"<br>▪ The condition of just 4 hospitals was rated poor, as an average score | WHO, UNDP, UNSCO and MOH (2010) |
| | - To evaluate the effectiveness of the medical equipment management cycle that currently in use in Governmental Health Facilities<br>- To suggest simple methods for the improvement of equipment management. | 2010 | ▪ 61.1% of respondents reported that there is no preventive maintenance system in their department.<br>▪ 83.7% of them reported that most of equipment that were malfunctioning were due to lack of spare parts | Murad (2010) |
| **Occupied Palestinian Territories (Israel)** | - To develop key performance indicator for: 1.performance management 2.Labour provision for maintenance.3.maintenance efficiency.<br>- To quantify the effects of users, building parameters and systems on the performance and maintenance of hospital buildings | 2003 | ▪ The Building Performance Indicator (BPI) analysis resulted indicating that the Maintenance Efficiency Indicator (MEI)<br>▪ The manpower source diagram<br>▪ The managerial span of control | Shohet (2003)<br>Shohet et al (2003)<br>Lavy and Shohet (2004)<br>Lavy and Shohet (2010)<br>Lavy (2006)<br>Lavy (2011) |

Table 2.3 Summary of related previous studies (continued)

| | | | | |
|---|---|---|---|---|
| **Saudi Arabia** | To audit the existing maintenance situation in government and private hospitals in the Kingdom of Saudi Arabia | 1999 | ▪ Maintenance staff has formal vocational qualifications and are provided training facilities.<br>▪ The system of working includes both preventive and breakdown maintenance and is fairly well developed. Maintenance facilities are of standard nature and various maintenance reports | Ikhwan and Burney (1999) |
| **Malaysia** | To develop maintenance achievement index (MAI) to benchmark the performance of building maintenance from a number of key performance indicators (KPIs). | 2012 | Building maintenance practitioners believe quality, safety, time, cost, functionality, and environmental friendliness can be considered as KPIs for building maintenance activities | (Yahya and Ibrahim, 2012). |
| | Proposes a Performance Measurement System (PMS) for the enhancement of FM specifically focusing on the maintenance delivery aspect. | 2011 | Common maintenance management systems applied for office building comprises of three major aspects namely Functional, Technical and Image | (NikMat et al , 2011) |
| | identifying factors causing poor maintenance in various types of buildings | 2010 | Lighting, HVAC, telecommunications and sanitation are considered to need most maintenance attention | (Zawawi et al, 2010). |
| | To determine and identify the factors contributing to rising maintenance costs. | 2010 | Five of the most influential variables were expectation of tenants, building materials, building services, building age and failure to execute maintenance at the right time | (Shah Ali et al , 2010) |

Table 2.3 Summary of related previous studies (continued)

| | | | | |
|---|---|---|---|---|
| **Malaysia** | To identify the maturity level of the maintenance organization in a specific hospital with regard to the effectiveness of their management of facility engineering maintenance (FEM) services | 2009 | The findings that the maintenance organization had not made much effort to accomplish their roles and responsibilities towards successful implementation of FEM services | (Ali, and Mohamad, 2009). |
| **Ghana** | To assess the current condition of public buildings, identify the underlying principal causes of poor maintenance of public buildings | 2010 | The maintenance problems the study observed have been influenced by the age of the buildings, lack or absence of a national maintenance policy, inadequate funds and high cost of maintenance, low capacity of maintenance staff, apathy and lack of patriotism on the part of occupants, pressure on buildings due to the number of users | (Cobbinah, 2010). |
| **Nigeria** | To examine the labour composition for maintenance works in the public hospital buildings in South-West, Nigeria | 2012 | ▪ The staff strength of the maintenance departments is inadequate and they are inexperience on hospital maintenance management.<br>▪ Majority of the users of public hospital buildings do not have access to any formal training on effective use of hospital facilities | (Afolarin, 2012) |

## 2.11 Concluding remarks for literature review

This chapter reviews the literature that are related to the present study to achieve the four objectives listed in chapter one. *The first objective* was to assess the operational conditions carried out by maintenance departments in public hospital building. Maintenance firstly was defined as combination of all the technical and administrative actions, including supervision, intended to retain an item, or restore it to a state in which it can perform a required function. Previous literature have listed three types of maintenance: preventive maintenance, corrective maintenance and immediate maintenance. Building defects considered as essential resource for maintenance activities, understanding common building defects and their types were essential, defects in the building was analyzed and took an overview of common defects in buildings. Maintenance daily work is important to determine the attitude of the maintenance departments. Daily and scheduled maintenance services provided to the end users of the building. Hospital building characteristics and their effect on the privacy of interior preparation and medical installation that required special maintenance procedure was mentioned to have a good background on hospital`s behavior.

*The second objective* was to determine factors affecting maintenance management of public buildings. Firstly the maintenance department structure, responsibilities and what activities was illustrated. Then maintenance aspects like functional, technical and image of the building and their performance dimensions was discussed. Deterioration, future needs and faulty of choice materials considered as factors influence maintenance in the design stage. While there were dissatisfaction of the approach to maintenance factors: poor specification of initial requirements, unclear aims and objectives and inappropriate frameworks. Maintenance cost factors were mentioned as building materials, building services, building age and failure to execute maintenance at the right time. The poor maintenance of public buildings factors: the age of the buildings, lack of maintenance culture, inadequate funds and high maintenance cost, pressure on building facilities by number of users and poor construction work and maintenance work done by maintenance personnel of the institution.

*The third objective* was to identify the key performance indicators for building maintenance and their measurements. Performance indicator (PI) was defined as a metric that measures the degree to which key functions (objectives) of an organization are being achieved. Building performance is complex, since different criteria in the building sector have differing interests and requirements. One of the complexity reasons the lack of consensus on what constitutes excellence in building assessment performance, covering the overlapping dimensions of social, economic, environment and technological factors. In construction projects, performance indicators were construction cost, construction time, cost predictability (design and construction), time predictability (design and construction), defects, client satisfaction with the product and client satisfaction with the service. In hospitals the main existing performance indicators as are:

1. Building performance indicator (BPI)
2. Maintenance efficiency indicator (MEI)
3. Annual maintenance of expenditure (AME)
4. Manpower sources diagram (MSD)
5. Managerial span of control (MSC)
6. Manpower utilization index (MUI)
7. Preventive maintenance ratio (PMR)
8. Average time to repair (ATTR)
9. Maintenance productivity (under development)
10. Urgent repair request indicator (URI)

As noticed from the previous research for the KPIs that Shohet (2003) and lavy (2006) were from the fewest researchers who developed KPIs for hospital maintenance while the other researchers have developed performance measurements or indicators for general organizations goals, time, quality and cost or in the field of construction to measure the contractor and the client satisfaction and other indicators.

In this study the applicable KPIs in the Gaza Strip hospitals will be limited for only four KPIs for due to the availability of data to measure the KPIs. These KPIs were selected from Shohet (2003), Shohet et al (2003), Lavy and Shohet (2004), Lavy and Shohet (2010), Lavy (2006), Lavy (2011), Park and Augenbro( 2003) and Pati, et al (2009) as follows:

1. Building performance indicator (BPI)
2. Maintenance efficiency indicator (MEI)
3. Annual maintenance of expenditure (AME)
4. Urgent repair request indicator (URI)

*The fourth objective* was to introduce a frame work which determined the prerequisites and the current situation of available resources and potential for applying the KPIs then demonstrates the stages. It may be considered as a tool to organize and control the work done on building`s maintenance. From the frame work it can be concluded the minimum requirements for the maintenance management.
It will be discussed in chapter 5 for further details.

Table 2.4 illustrates the main references that have been researched for achieving the objectives of this study which was collected from the literature review

Table 2.4 Main references which covers the four objectives

| # | Objective | Main references |
|---|---|---|
| **1** | Assess the operational conditions carried out by the maintenance departments of public hospital buildings | Ikhwan and Burney (1999), Lind and Muyingo (2012), Horner et al (1997), Bin Hashem (2006), Mutia, et. al (2012), Dhillon (2002), OLA (2000), Cobbinah (2010) |
| **2** | Determine factors affecting maintenance management of public hospital buildings. | Adenuga et al. (2007), Cooper and Jones (2008), Yahya and Ibrahim(2012), Cooper and Jones (2008), NikMat et al (2011), OLA (2000), Cobbinah (2010), Shah Ali et al (2010) |
| **3** | Measure the key performance indicators.<br>1. Building performance indicator (BPI)<br>2. Maintenance efficiency indicator (MEI)<br>3. Annual maintenance of expenditure (AME)<br>4. Urgent repair request indicator (URI) | Shohet (2003), Shohet et al (2003), Lavy and Shohet (2004), Lavy and Shohet (2010), Lavy (2006), Lavy (2011), Alwaer and Croome (2010), Park and Augenbro (2003), Pati, et al (2009) |
| **4** | Specify the minimum requirements for the management of maintenance (further details in chapter 5) | Ma´rquez et al (2009), Carlos et al (2012) |

# Chapter 3

# Methodology

## 3.1 Overview

Research has its special significance in solving various operational and planning problems. The main role of this chapter is to describe the research method in clear way, determine its type, what was the methods used to collect data and how it will be analyzed. This chapter represents the methodology of the study from being the research title as an idea till the analysis of data, tools used and results which obtained during the period of the research.

As mentioned in chapter one there are four objectives for this research:

1. Assess the operational conditions carried out by the maintenance departments of public hospital buildings in Gaza strip.
2. Determine factors affecting maintenance management of public hospital buildings.
3. Measure the key performance indicators.
4. Specify the minimum requirements for the management of maintenance.

## 3.2 Research flow chart

Research design and flow chart divided into 11 steps

Step 1: Initiating the research idea with the supervisor and its applicability in Gaza strip.

Step2: Beginning of gathering some information about the hospital building maintenance and the health situation how it's included in construction management.

Step 3: Writing the proposal for the research describing brief summary how the research will be look like and get the supervisor approval.

Step 4: Starting an initial survey in hospitals to determine what type of information needed.

Step 5: Reading literature review about the key performance indicators and its relation in hospitals building maintenance and preview previous research findings about what's have been done in Gaza strip and other countries.

Step 6: Design the questionnaire and the performance indicators.

Step 7: Conducting a pilot study for the questionnaire through experts in the field and modifying it within the expert comments and throughout the feedback obtained.

Step 8: Starting to fill the questionnaire by the researcher "interviewed questionnaire" through visiting each hospital maintenance department and meeting the engineers.

Step 9: Evaluate the performance of hospital building using the performance scale which was taken from PhD study (Lavy, 2006).

Step 10: Statistical analysis of data and extract results using descriptive statistics methods (such as mean values, standard Deviations, etc.) using Microsoft excel 2007, as well as statistics tests using SPSS version 20.

Last step to: Create from the results a proposed framework for KPI in hospitals maintenance buildings in Gaza Strip.

All these steps are illustrated in the research methodology flow chart showed in figure 3.1.

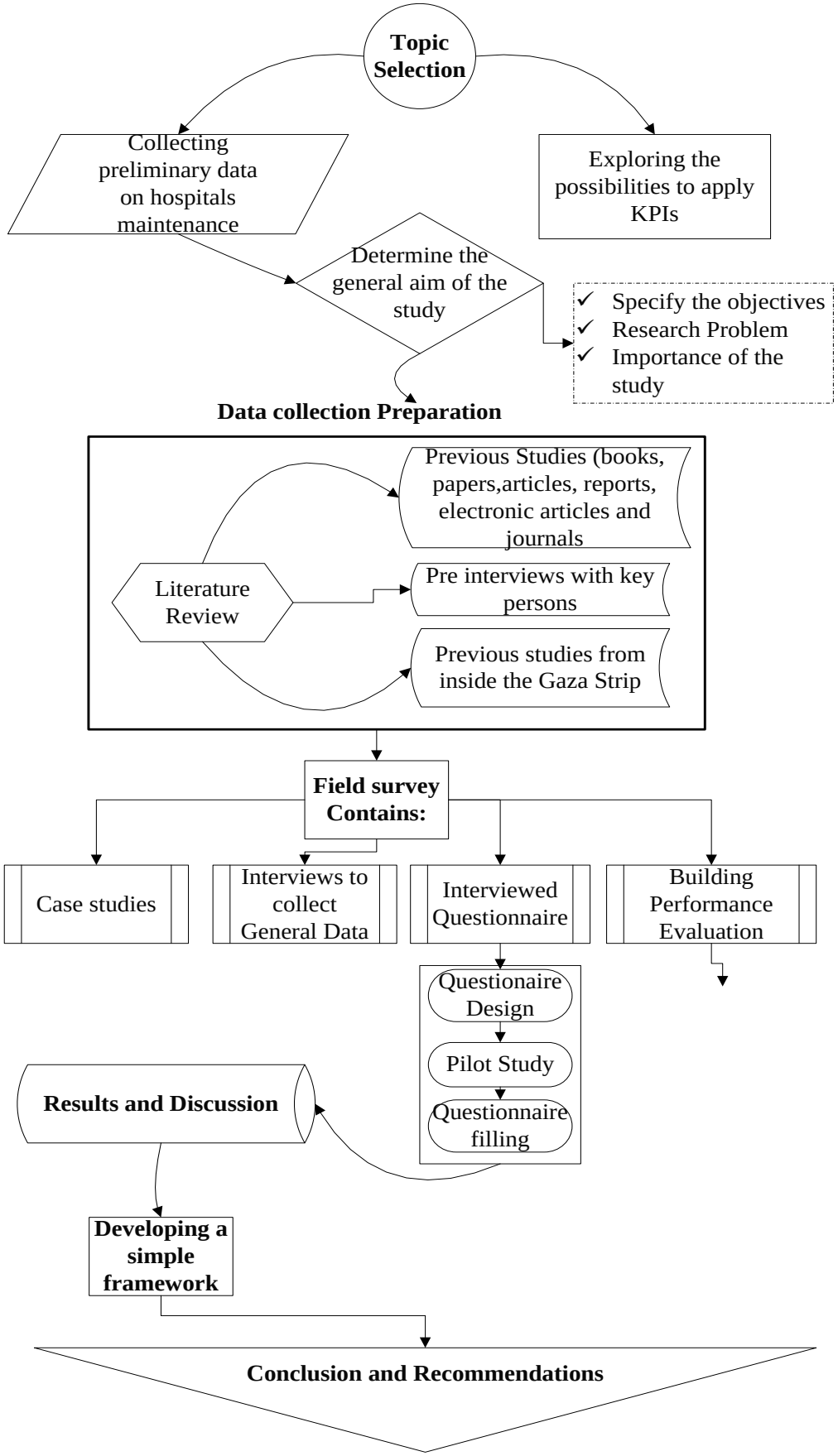



Figure 3.1Research methodology flow chart

## 3.3 Research period

The study started on April 2012 when the initial proposal was approved, literature review and preliminary field survey until September 2012. Questionnaire design and piloting during October and November. Data collection using the questionnaire was conducted from November till the end of 2012. Analysis of the results and writing up during January and February 2013.

## 3.4 Research population and sample size

There are 30 hospitals in Gaza Strip 13 of them are governmental hospitals which are administrated by Ministry of Health (Table 3.1) is the targeted population. The hospitals are categorized into small size, big size and complex according to the MoH. This population is selected because of its importance and the big role that hospitals play in Palestinian people`s life in the Gaza strip. The population is sufficiently small, a full population 'sample' will be researched (Fellows and Liu, 2008).

Table 3.1 MOH hospitals "population"

| No. | Hospital Name | Geographic Location | Hospital size | Type |
|---|---|---|---|---|
| 1 | Bait Hanon | North | Small | General |
| 2 | Kamal Odwan | North | Big | General |
| 3 | Al Naser for Pediatrics | Gaza | Big | Specialized |
| 4 | Ophthalmic | Gaza | Small | Specialized |
| 5 | Psychiatric hospital | Gaza | Small | Specialized |
| 6 | Rantisi Specialized Pediatrics | Gaza | Small | Specialized |
| 7 | Dorra | Gaza | Small | Specialized |
| 8 | Shifa | Gaza | Complex | General |
| 9 | Al Aqsa | Middle | Big | General |
| 10 | Nasser | Khanyonis | Complex | General |
| 11 | European Gaza Hospital | Khanyonis | Big | General |
| 12 | Abo Yosef Al Najjar | Rafah | Small | General |
| 13 | Tal Sultan (Hilal Emarati) | Rafah | Small | Delivery (Maternity) |

## 3.5 Sample characteristics

The 13 hospitals are distributed into 5 governorates in the Gaza strip. The hospitals are grouped into three types there are: general, specialized and maternity. The three categories small, big and complex, small means hospital capacity in beds equal or smaller than 100 bed, big means hospital capacity in beds equal greater than 101 bed, while complex indicates that there are more than specialized hospital. This research takes into consideration two aspects in governmental hospitals:

1. Maintenance departments situations
2. Health facility buildings performance

The maintenance departments are centered in the five main governorates each center responsible for the maintenance services in the nearby geographic location hospitals and primary health care centers in the governorates. Every hospital has a representative for the maintenance department which has its residence staff. Table 3.2 shows the responsibility hospitals for each maintenance center.

Table 3.2 Maintenance department centers in the Gaza strip

| # | Maintenance center | Hospitals Under responsibility |
|---|---|---|
| **1** | North | Kamal Odwan and Bait Hanoon hospitals |
| **2** | Gaza | Shifa, Al Naser for Pediatrics, Ophthalmic, Psychiatric hospital, Rantisi Specialized Pediatrics, and Dorra hospital |
| **3** | Middle | Al Aqsa hospital |
| **4** | Khanyonis | Nasser complex |
| **5** | Rafah | EGH, Abo Yosef Al Najjar and Tal sultan |

One of the key performance indicators is building performance. It needs to make a field survey included actual performance scores of 51 main building components (see appendix B). as well as required performance scores of 10 building systems: structure, exterior envelope, interior finishes, electricity, sanitary systems, HVAC, fire protection, elevators, communications and low-voltage, and medical gases (see appendix B).

Table 3.3 shows that 21 building surveyed out of 38 for the following reasons: Shifa hospital includes 15 buildings only three of them surveyed because some of building is going to be demolished. In other hospitals and in Shifa there are buildings under construction and expansion, some building are not health facilities only administrative so these buildings were not surveyed.

Table 3.3 hospital building numbers

| No. | Hospital Name | No. of existing building | No. of surveyed buildings |
|---|---|---|---|
| **1** | Bait Hanon | 2 | 1 |
| **2** | Kamal Odwan | 2 | 2 |
| **3** | Al Naser for Pediatrics | 1 | 1 |
| **4** | Ophthalmic | 1 | 1 |
| **5** | Psychiatric hospital | 3 | 2 |
| **6** | Rantisi Specialized Pediatrics | 1 | 1 |
| **7** | Dorra | 1 | 1 |
| **8** | Shifa | 15 | 3 |
| **9** | Al Aqsa | 1 | 1 |
| **10** | Nasser | 3 | 2 |
| **11** | European Gaza Hospital | 5 | 3 |
| **12** | Abo Yosef Al Najjar | 2 | 2 |
| **13** | Tal Sultan (Hilal Emarati) | 1 | 1 |
| | **Total** | 38 | 21 |

## 3.6 Research location

This research was conducted in the Gaza Strip area in all the five governorates hospitals: North, Gaza, Middle, Khanyonis and Rafah governorates. The interviewed questionnaire was done with the maintenance department staff in each hospital. As the number of maintenance department is limited and 77.6% of the staff is technicians and 8% are bio medical engineers, the interviewed questionnaire was with the head of maintenance department manger in the 13 hospitals.

## 3.7 Data collection

After reviewing the literature and conducted the pilot survey on the situation of hospitals in Gaza strip, the most approximated tool used in this research was questionnaire and case studies. Questionnaire is considered as the heart of a survey operation.

The questionnaire included the maintenance departments in hospitals status, maintenance activities, staff, maintenance problems and also included evaluation of the performance of the building in the targeted hospitals. The evaluation used in this study was adopted from lavy, 2011 PhD study which presented how to measure the building performance indicator and the maintenance efficiency indicator. There was a scale used to follow how to give marks on the performance of the building. The two case studies will be presented in the next chapter to show the most common type of maintenance held in MOH hospital facilities which is corrective maintenance.

## 3.8 Questionnaire design

A questionnaire was designed based on previous literature review. It was modified according to the pilot study

The questionnaire included five parts of questions, these parts was designed to meet the first three objectives. The questionnaire aimed to identify operational state of maintenance departments and the key performance indicators in hospitals of the Gaza Strip. The questionnaire included performance evaluation for the buildings in the hospitals this evaluation and its performance scale were taken from Lavy (2006) PhD dissertation after his acceptance. The questionnaire (see Appendix A) filling was by the researcher, almost each hospital needed many visits to complete the questionnaire and to evaluate the buildings.

*Part one* was about general information regarding the hospital buildings , location, building area, number of building and its occupancy year, hospital bed occupancy, type of maintenance done and maintenance expenditures.

*Second part* included performance measurement dimensions like responsiveness, relevance and delivering characteristics were asked as yes or no questions.

*Third part* was about the maintenance staff number and the categorizations and their specialty.

*Fourth part* listed the maintenance department activities in hospitals buildings, which includes the medical equipment, mechanical equipments and civil works done. The maintenance staff skills, trainings, motivation and if there training on how to conduct assessment for building maintenance.

*The fifth part* gathered the needed performance evaluation scores and financial data to measure the KPIs. Table 3.4 illustrated how the questionnaire covers the first three objectives and the reference of each part.

Table 3.4 Questionnaire parts cover the main objectives and references

| # | Objective | Questionnaire parts | References |
|---|---|---|---|
| 1 | Assess the operational conditions carried out by the maintenance departments of public hospital buildings in Gaza strip. | **Part 1. General Information of the Selected Hospitals Buildings** | Shohet et. al (2003)<br>Lavy (2006)<br>Zawawi and Kamaruzzaman (2009)<br>Zawawi et.al (2010)<br>Afolarin (2012)<br>Lind and Muyingo (2012)<br>Horner et al (1997)<br>Cooper and Jones (2008) |
| | | Characteristics of the facility<br>▪ Geographical category<br>▪ Number of surveyed buildings<br>▪ Built floor area<br>▪ Total number of buildings<br>▪ Total number of patient beds<br>▪ Number of day-care patient beds<br>▪ Age of the building<br>▪ Maintenance Types | |
| | | **Part 3.Information of the Selected Hospitals Buildings Maintenance Department** | Lavy (2006)<br>Afolarin (2012)<br>Zawawi and Kamaruzzaman (2009)<br>Zawawi et al (2010)<br>Bin Hashem (2006) |
| | | No of employees and their categorization | |
| | | **Part 4 Maintenance Department Activities in hospitals building** | Mutia, et al (2012)<br>Dhillon (2002)<br>OLA (2000)<br>Bin Hashem (2006) |
| | | ▪ Medical Equipments Maintenance procedure<br>▪ Plumbing and Water Systems Maintenance<br>▪ Civil works activities frequency | |

Table 3.4 Questionnaire parts cover the main objectives and references (continued)

| # | Objective | Questionnaire parts | References |
|---|---|---|---|
| 2 | Determine factors affecting maintenance management of public hospital buildings | **Part 2 Performance measurement dimensions** the performance of building maintenance management department<br>▪ Timeliness<br>▪ Delivering characteristics<br>▪ Relevance<br>▪ Responsiveness | Yahya and Ibrahim(2012)<br>Cooper and Jones (2008)<br>NikMat et al (2011) |
| | | **Part 4 Maintenance Department Activities in hospitals building** | |
| | | ▪ Problems in hospital building maintenance<br>▪ Major sources of maintenance related complaints<br>▪ major cause of non maintenance of public building | Cooper and Jones (2008)<br>Adenuga et al. (2007)<br>Cobbinah (2010)<br>Shah Ali et al (2010) |
| | | **Part 4 Maintenance Staff skills and behavior factors**<br>▪ Employees receive the training they need to complete their tasks<br>▪ safely and competently<br>▪ Motivation<br>▪ Historical trends in maintenance. | Afolarin (2012)<br>Cobbinah (2010)<br>OLA (2000) |

Table 3.4 Questionnaire parts cover the main objectives and references (continued)

| # | Objective | Questionnaire parts | References |
|---|---|---|---|
| **3** | Measure the key performance indicators. | **Part 5 Key performance indicators** | Shohet et al (2003)<br>Lavy (2006)<br>Lavy and Shohet (2004)<br>Lavy and Shohet (2010),<br>Lavy (2011), Alwaer and Croome (2010), Park and Augenbro (2003),<br>Pati, et al (2009) |
| | | Building performance indicator (BPI)<br>Life cycle cost | |
| | | Maintenance efficiency indicator (MEI) | |
| | | Annual maintenance of expenditure (AME) | |
| | | Urgent repair request indicator (URI) | |

## 3.9 Pilot study

It is a necessary practice that the survey instrument should be piloted to measure its validity and reliability and test the collected data. The pilot study was conducted by distributing the prepared questionnaire to ten experts who have experience in the same field of the research. Eight experts were from the MOH maintenance departments and one expert was from UNDP and one expert from private engineering consultation office. The experts have got the Bachelor degree in civil engineering, electrical engineering and mechanical engineering however two of them have master degree in the engineering fields like: bio medical engineering and electrical engineering. Their experience years in the maintenance start from 3 years till 25 years.

Through meeting the experts and have their comments and editing, all the notes have been focused on how to insert the field of medical and mechanical equipment maintenance and notes on the financial data and its unavailability in the detailed way that have been existed in the fifth part of the questionnaire. Advices were about adding a part discussing the medical equipments. There were suggestions also to add that there are alternatives for electrical supply due to the electrical power cuts in the Gaza Strip. But it was outside of the research range. All the notes have been taken in consideration and the questionnaire amended and improved to be ready for distributing and gathering data.

## 3.10 Data measurement and analysis

The data analysis was in both qualitative and quantitative methods. The Data analysis will be made utilizing (SPSS 20). The researcher would utilize the following statistical tools:

1) Frequency and descriptive analysis
2) Shapiro-Wilk test is used to test the normality of data.
3) Spearman Rank correlation is used to determine whether there is evidence of a linear relationship between two variables that are not normally distributed. Correlation coefficient used between pressure on facility/building due to number of occupants and total area

4) Mann-Whitney test (test if there is a statistical significant difference between two mean ranks the ranks of two mean ranks. Used for lack of maintenance culture with training programme for users on how to effectively manage the facilities within the hospital buildings

The analysis and measurements of the KPIs and their values if they are in the specified range or not as in the following sections. There are four performance indicators listed in this research each indicator depends on the other the indicators are: (1) Maintenance Efficiency Indicator (MEI); (2) Annual Maintenance Expenditure (AME); (3) Building Performance Indicator (BPI); and (4) Urgent Repair indicator (URI).

### 3.10.1 Methodological assumptions for KPIs calculations

As performance indicators based on Shohet et al (2003) and Lavy (2006) researches this research will committed to their basic assumptions but with some modification for the Gaza strip hospitals actual status and availability of information required. According to lavy (2006) building have been classified into 10 building systems which have 51 component (see appendix B). Some modification was done on theses component to adequate with Gaza strip hospital building the accommodation as in table 3.5.

Table 3.5 Modification for building system components

| # | **Building system** | **Existing Component** | **Modified component** |
|---|---|---|---|
| 1 | Structure | Columns | - |
| | | Beams | |
| | | Slabs | |
| 2 | Exterior Envelope | Windows | No exterior cladding |
| | | Exterior walls | |
| | | Roofing | |
| | | Exterior claddings | |
| 3 | Interior finishes | Doors | No Acoustic tiles |
| | | Plaster | |
| | | Paintings | |
| | | Ceramic tiles | |
| | | Acoustic tiles | |
| | | Flooring | |
| 4 | Electricity | Electricity system | - |
| | | Electric boards | |
| | | Transformers | |
| | | Pipes and ducts | |

Table 3.5 Modification for building system components (continued)

| # | Building system | Existing Component | Modified component |
|---|---|---|---|
| | Electricity | Switching equipment | |
| | | Conductors and cables | |
| | | Grounding protection | |
| | | Electric accessories | |
| | | Lighting accessories | |
| | | Peripheral lighting | |
| 5 | Sanitary system | Water supply system | Sanitary accessories included the sewage network |
| | | Sanitary accessories | |
| 6 | HVAC | Compressors | There is no unified system for air-conditioning Split units, central unit and chiller All components was not asked about |
| | | Condensers | |
| | | Fan-coil units | |
| | | HVAC pipes | |
| | | Pumps | |
| | | Ductworks | |
| | | Electric boards for HVAC system | |
| | | Window units | |
| | | Bellows / fans | |
| | | Cooling towers | |
| 7 | Fire protection | Fire detection | Mainly only the fire detection and fire extinguishing |
| | | electric boards Manual / automatic | |
| | | fire extinguishing | |
| 8 | Elevators | Machine room | Its outsourced responsibility dealed as one element |
| | | Control panel | |
| | | Elevators doors | |
| | | Chambers | |
| | | Suitability to handicapped | |
| | | Pneumatic delivery system | |
| 9 | Communications and low-voltage | Public announcement | Only the Telephone system and public announcement in some building |
| | | Telephone system | |
| | | Alarm | |
| | | Patient-nurse calling system | |
| | | Building control system | |
| 10 | Medical gases | Medical gases system | - |
| | | (piping, boards, accessories | |

The assumptions and modifications will be as follows:

4 The weight of all components in each building system is identical; all components included in the same building system have a similar effect on the system's performance. This assumption, divided the buildings into 10 main building systems, and these systems were subdivided into 51 main building components (see appendix B) that exist in a typical hospitalization building, and this assumption makes computation of the system's performance score faster and easier.

- The weight of each system in the Building Performance Indicator is not calculated according to the ratio between the system's Life Cycle Costs and the building's Life Cycle Costs because of unavailability of detailed of the required financial records and data in Gaza strip hospitals buildings.
- The performance of each facility system and the total BPI for the entire facility are calculated according to the floor area of the surveyed buildings. This means that a larger building has a greater effect on actual performance than does a smaller one.
- The area-based weighting method is assumed to be the most appropriate for the calculations since the buildings in a facility are represented in an objective manner, unbiased on subjective views.

- Each component in the building was evaluated according to the Building Performance Indicator (BPI) method (Shohet, 2003) and (Lavy, 2006) using a 100-point rating scale, in which 20 represents the lowest score and 100 the highest. Based on technical scales those describe the physical condition of each component (see Appendix B). The values of these BPI reflect the level of performance of the facility and its systems, according to the following categories:

    - A performance score higher than 80 points indicates that the system is in Good or better than good condition.
    - A performance score of between 70 and 80 points indicates that the state of the system is such that some of the components are in Marginal condition, i.e. some preventive maintenance measures must be taken.

- A performance score of between 60 and 70 points indicates a state of Deterioration, i.e. preventive and breakdown maintenance activities must be carried out.
- A performance score of less than 60 points means that the system is in a Run-down condition, and as a result, some of its components must be replaced.

### 3.10.1.1BPI calculation

**To** calculate the BPI there is some values must be calculated first (all equations listed from Lavy (2006) research) :

1. calculate Actual performance score for system j in building i using the scale in appendix B using equation 3.1

$$AP_{i,j} = \frac{\sum_{K=1}^{n} AP_{i,j,k}}{n} \quad \text{..... Eq. 3.1}$$

Where;

APi,j : Actual performance score for system j in building i;
APi,j,k : Actual performance score for component k of system j in building i.
n : Number of components in a system.

2. The Annual Equivalent Value of the Life Cycle Costs (LCC) is calculated for each component using financial equation which uses reinstatement values, and replacement and maintenance costs of all the components included in a building, this is a financial weight that indicates the ratio of the system's LCC in a building.

$$LCC_{i,j,k} = \left\lfloor C_{i,j,k} + R_{i,j,k} \times sr(\text{int}, dlc_{i,j,k}) \times rp(\text{int}, NR_{i,j,k} \times dlc_{i,j,k}) \right\rfloor \times pr(\text{int}, DLC_i) + M_{i,j,k}$$

..... Eq. 3.2

Where:

LCCi,j,k : Annual Equivalent Value of Life Cycle Costs for component k of system j in building i [$US per sq-m];

Ci,j,k :Reinstatement value for component k of system j in building i [$US per sq m];

Ri,j,k :Replacement cost for component k of system j in building i [$US per sq-m]

dlci,j,k :Designed Life Cycle for component k of system j in building i [years]

NRi,j,k :Number of replacements during Design Life Cycle of component k of system j in building i

DLCi : Designed Life Cycle for building i [years].

Mi,j,k: Annual maintenance cost for component k of system j in building i [$US per sq-m]

sr :Future value annuity factor;

int :Annual interest rate [%];

rp : Annuity present value factor; and

pr : Present value annuity factor

***Note:*** all the values in step 2 wasn't obtained because it needs accurate official numbers especially reinstatement value, replacement cost ,number of replacements and annual maintenance cost for each component which needs records for each system hoe much maintenance cost us dollar per square meter.

$$BPI_i = \sum_{j=1}^{10} (AP_{i,j} * \frac{LCC_{i,j}}{LCC_I}) \quad \text{.....Eq. 3.3}$$

The life cycle cost ratio or weight $\frac{LCC_{i,j}}{LCC_I}$ will be considered as not existed because of its unavailability in MOH maintenance departments as an official number.

$$BPI_i = \sum_{j=1}^{10} (AP_{i,j} * \frac{LCC_{i,j}}{LCC_I}) \quad \text{.....Eq. 3.4}$$

So the building performance will be calculated based on area weighting method as following Equations

$$P_j = \frac{\sum_{i=1}^{NBS} AP_{i,j} \times TOA_i}{\sum_{i=1}^{NBS} TOA_i} \quad \text{.....Eq. 3.5}$$

$$BPI = \frac{\sum_{i=1}^{NBS} BPI_i \times TOA_i}{\sum_{i=1}^{NBS} TOA_i} \quad \text{.....Eq. 3.6}$$

Pj – Building Performance Indicator for system j;

NBS – Number of buildings surveyed;

TOAi – Total floor area of building i [sq-m]; and

BPI – Building Performance Indicator for the facility

### 3.10.1.2Total Annual Maintenance Expenditure (TAME)

It computes the actual total annual maintenance expenditure for the facility. The following assumptions were used in the development of this procedure: Each day-care patient bed equals one-third of an acute-care patient bed in the facility. The reason for this is that a day-care patient bed is used for about 8 hours a day, while an acute-care patient bed is used for 24 hours a day (lavy, 2006).

The total equivalent number of patient beds in a facility is calculated based on assumption using Equation 3.7

$$NOB = ACB + \frac{1}{3} \times DCB \quad \text{.....Eq. 3.7}$$

Where:

NOB – Total number of equivalent patient beds in the facility;

ACB – Total number of acute-care patient beds in the facility; and

DCB – Total number of day-care patient beds in the facility.

Then, the AME is calculated as the ratio between the TAME and the facility floor using Equation 3.8

$$AME = \frac{TANME}{FA} \quad \text{.....Eq. 3.8}$$

Where:

TAME – Total Annual Maintenance Expenditure [$US]; and

FA –Total built area of the facility [sq-m].

$$AMEPB = \frac{TANME}{NOB} \quad \text{.....Eq. 3.9}$$

Where:

AMEPB – Annual Maintenance Expenditure per patient bed [$US per equivalent patient bed].

### 3.10.1.3 Maintenance efficiency indicator (MEI)

Indicates the efficiency with which maintenance activities are implemented. The MEI ranges of values for healthcare facilities were defined as:

(1 Value below 0.37 represents a state of low budgetary investment or high maintenance resource utilization efficiency, or both;

(2 0.37<MEI≤0.52 represents the desirable situation for a maintenance department, indicating reasonable use of maintenance resources. and

(3 MEI>0.52 indicates high inputs relative to the actual performance. Such high index values may express high maintenance expenditures, low physical performance or a combination of these two extreme situations.

The Maintenance Efficiency Indicator is calculated using equation as presented in Lavy (2011) Equation 3.10

$$MEI = \frac{AME}{BPI \times FAC(y)} \quad \text{.....Eq. 3.10}$$

Where

MEI – Maintenance Efficiency Indicator;

AME – Annual Maintenance Expenditure [$US per sq-m];

BPI – Building Performance Indicator for the facility; and

FAC(y) – Facility coefficient for year y.

***But in this study ) – Facility coefficient for year is neglected due unavailability of financial data required to be calculated***

Shohet et al (2003) describe the calculation of the maintenance efficiency indicator as follows

$$MEI = \frac{AME}{AC(y)} \times \frac{1}{BPI} \times \frac{1}{OC} \times ic \quad \text{..... Eq. 3.11}$$

Where;

ACy: is the age coefficient for year y seeing table 3.6.

BPI: is the monitored building performance indicator,

OC: is the occupancy coefficient, see appendix D

ic: is the prices index (not calculated in this study because of its unavailability.

Table 3.6 Age coefficients for hospitalization buildings of various ages

| Age of building (years) | Age coefficient ACy |
|---|---|
| **05** | 0.55 |
| **10** | 0.67 |
| **15** | 0.90 |
| **20** | 1.18 |
| **25** | 1.33 |
| **30** | 1.22 |
| **35** | 1.20 |
| **40** | 1.30 |
| **45** | 1.22 |
| **50** | 1.05 |

### 3.10.1.4 The urgent repair request index (URI)

Park and Augenbro (2003) mentioned a high value of URI means that the engineering staffs are heavily engaged in urgent repairs, being distracted from carrying out normal corrective and preventive works, and in the long term the building will suffer from loss of business and prestige defined as:

$$URI = \frac{UR}{UR + GR}$$ Where;

UR: is the number of urgent repair requests arising from guests and in-house staff,

GR: is the number of general requests for repair of the building facilities.

It should be noted that if the engineering staff are able to carry out maintenance on a continuous basis to keep the equipment and systems in good order, the amount of urgent repairs would be reduced.

# Chapter 4

# Results and discussion

## Introduction

This chapter presents the findings, analyses and outcomes of the questionnaire and field survey that was carried out in 2012. The field survey implemented in this research comprised thirteen public hospital facilities in Gaza strip. The main findings are summarized in this chapter which is divided into two main parts: 1. Research hypothesis; 2. Research objectives:1) Maintenance department operational current status; 2) factors affecting maintenance management; 3) Performance indicators for the surveyed buildings.

## 4.1 Research hypothesis

To test the hypothesis the Fisher Exact Test was used, which test the relationship between two nominal (qualitative) variables for 2 X 2 tables). Also the frequency analysis showed the results.

4.1.1 **The null hypothesis ($H_0$):** There is no significance association between the scheduled plans for building maintenance and equipment hospital maintenance plan in public hospital buildings in Gaza Strip.

**The alternative hypothesis ($H_1$)** There is significance association between the scheduled plans for building maintenance and equipment hospital maintenance plan in public hospital buildings in Gaza Strip. Table 4.1 shows P-value = 0.706, this result *indicates that there is no relationship* between the department have a written long-range plan for building maintenance and repairs that extends out a minimum of three to five years and the hospital have maintenance plan for equipment. *The null hypothesis is accepted because* the P-value is larger than the level of significance $\alpha = 0.05$.

Table 4.1 First hypothesis P value results

| | Answer | # | The hospital have maintenance plan for equipment | | Total | P-value |
|---|---|---|---|---|---|---|
| | | | Yes | No | | |
| The department have a written long-range plan | yes | N | 3 | 7 | 10 | 0.706 |
| | | % | 30.0% | 70.0% | 100.0% | |
| | no | N | 1 | 2 | 3 | |
| | | % | 33.3% | 66.7% | 100.0% | |
| Total | | N | 4 | 9 | 13 | |
| | | % | 30.8% | 69.2% | 100.0% | |

4.1.2 **The null hypothesis ($H_0$)**: There is no significant coordination between maintenance staff and users of the hospital departments for the poor maintenance management of public hospital buildings in Gaza Strip.

**The alternative hypothesis ($H_1$)**: There is significant coordination between maintenance staff and users of the hospital departments for the poor maintenance management of public hospital buildings in Gaza Strip. Table 4.2 shows P-value = 0.706, this result indicates that there is no relationship between the maintained item related to the maintenance request and training programme for users on how to effectively manage the facilities within the hospital buildings.

*The null hypothesis is accepted because* the P-value is larger than the level of significance $\alpha = 0.05$.

The obtained results are in line with the findings of Adengua et al, 2007.

Table 4.2 Second hypothesis P value results

| | | | Are there training programme for users | | Total | P-value |
|---|---|---|---|---|---|---|
| | | | yes | No | | |
| The maintained item related to the maintenance request | yes | N | 2 | 7 | 9 | 0.706 |
| | | % | 22.2% | 77.8% | 100.0% | |
| | No | N | 1 | 3 | 4 | |
| | | % | 25.0% | 75.0% | 100.0% | |
| Total | | N | 3 | 10 | 13 | |
| | | % | 23.1% | 76.9% | 100.0% | |

## 4.2 Research objectives results

***The first objective*: Assess the operational conditions carried out by the maintenance departments of public hospital buildings in Gaza strip.**

**4.2.1** Maintenance department's current status and general information

**a) Hospital spatial region**

Gaza strip is considered as coastal region as it's located on the shore of the Mediterranean Sea however the eastern part can be considered as in land area. See table 4.3 and figure 5.1 shows the spatial location of the hospital buildings.

Table 4.3Hospital spatial regions

| # | Hospital | Spatial region |
|---|---|---|
| **1** | Shifa | coast |
| **2** | Dorra | In land |
| **3** | Rantisi | coast |
| **4** | Pediatric | coast |
| **5** | Ophthalmic | coast |
| **6** | Psychiatric | coast |
| **7** | Nasser complex | coast |
| **8** | European Gaza Hospital | In land |
| **9** | Al Aqsa | coast |
| **10** | Al Najjar | In land |
| **11** | Tal sultan | coast |
| **12** | Kamal Odwan | coast |
| **13** | Bait Hanoon | In land |

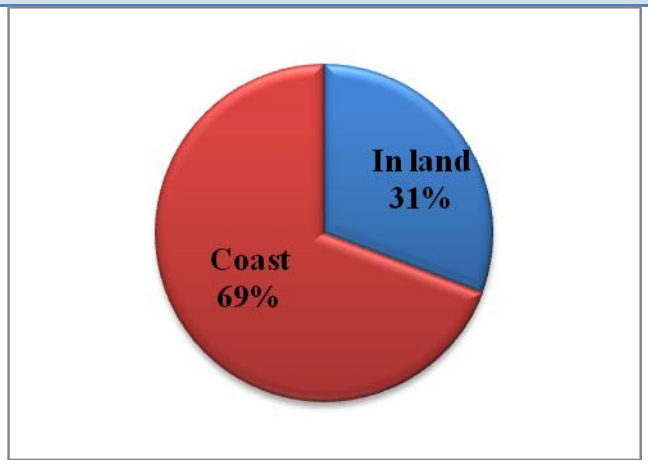



Figure 4.1 Hospital spatial locations types and their percentages

**b) Buildings age**

As shown in table 4.4 and figure 4.2 the maximum existing surveyed hospital building ages is 51 years, while the average Gaza Strip hospital ages is 21 years and the minimum age is 7 years since operation date. Considering that Shifa complex has the oldest building in the Gaza Strip hospitals: (Medicine building and the Respiratory building (مبني الصدرية والباطنة)) which is recommended by the maintenance management in Shifa hospitals to be demolished. So they are not considered in this research.

Table 4.4 Hospital building age

| # | Hospital | Building name | Building age (years) | Floor area sq-m |
|---|---|---|---|---|
| 1 | Shifa | Surgery | 33 | 1652 |
| 2 | | outpatient | 33 | 2058 |
| 3 | | Burn | 8 | 700 |
| 4 | Dorra | Main building | 13 | 750 |
| 5 | Rantisi | Main building | 7 | 2500 |
| 6 | Naser Pediatric | Main building | 51 | 2000 |
| 7 | Ophthalmic | Main building | 17 | 940 |
| 8 | Psychiatric hospital | Rehabilitation | 51 | 230 |
| 9 | | Departments | 51 | 250 |
| 10 | Nasser complex | Tahreer building | 18 | 1400 |
| 11 | | Nasser building | 51 | 2200 |
| 12 | European Gaza Hospital | A | 13 | 2000 |
| 13 | | B | 13 | 2000 |
| 14 | | C | 13 | 2000 |
| 15 | Al Aqsa | Main building | 13 | 1800 |
| 16 | Al Najjar | Old building | 13 | 950 |
| 17 | | New building | 8 | 800 |
| 18 | Tal sultan | Main building | 7 | 800 |
| 19 | Kamal Odwan | Emergency | 8 | 740 |
| 20 | | Departments | 17 | 750 |
| 21 | Bait Hanoon | Main building | 8 | 1090 |

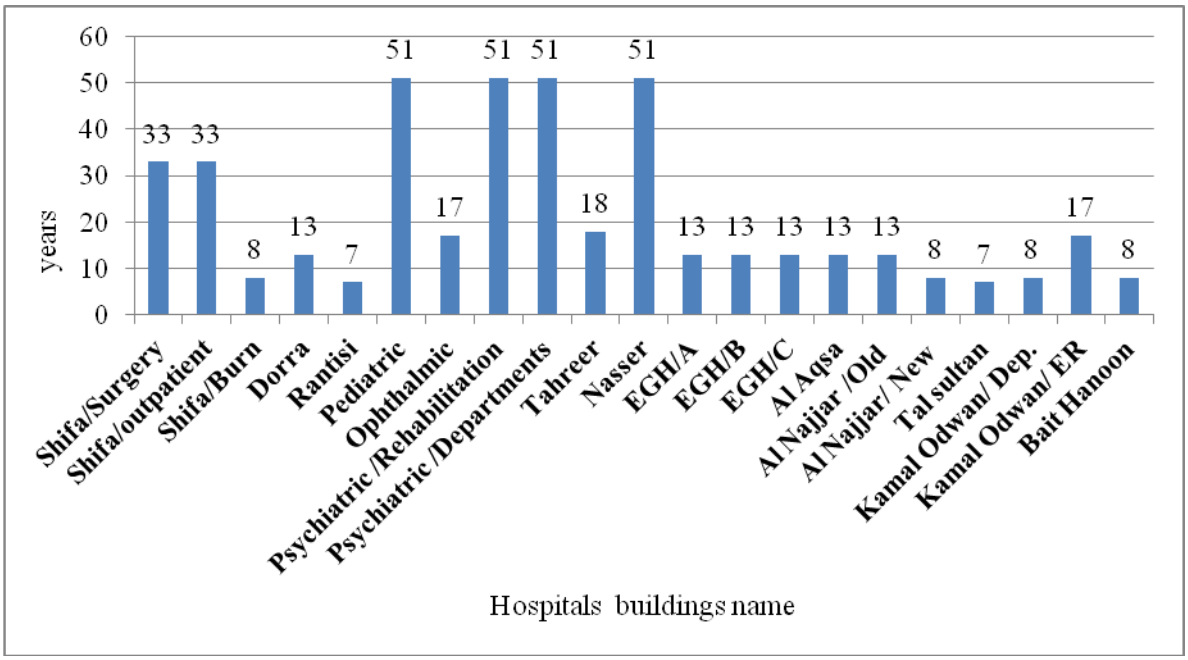



Figure 4.2 Hospital building actual ages

Figure 4.3 represents that about 43% of hospitals are in their second decade this emphasizes that most of hospitals was built and operated since Palestinian MOH establishment in 1995 and about 29% of hospitals in their first decade especially after Intifadat Al Aqsa in 2000. 19% of the hospitals their ages more than 40 years built under the administrative of Egyptian and Israeli administrative this indicates that the health in the Gaza strip has got a lot of priority since the Shifa complex is the biggest health facility in Palestinian territories.

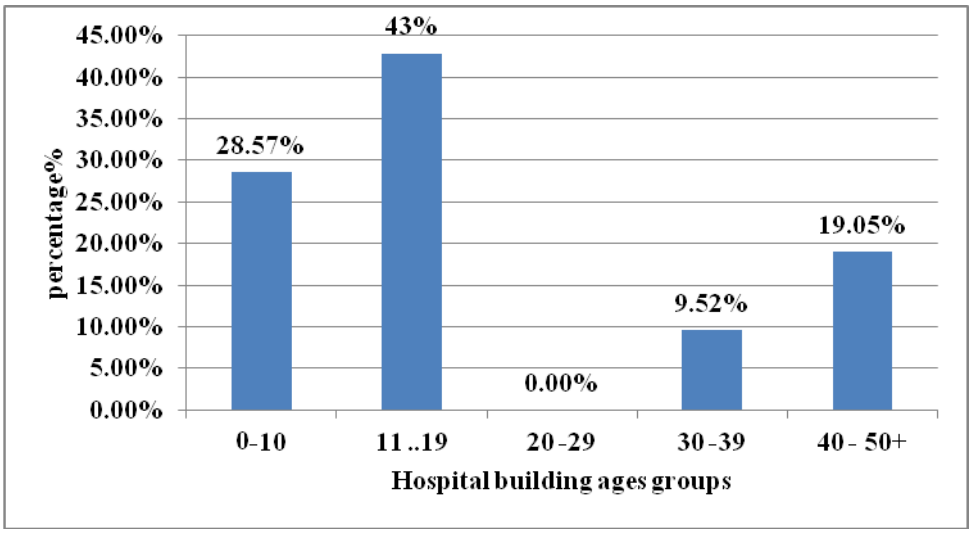



Figure 4.3 Building age categories

### c) Total number of employees

The total number of employees in the surveyed hospital buildings included (physicians, nurses, and staff) was taken from MoH report, 2011. Table 4.5 shows the numbers of employees and patients bed for each hospital, figure 4.4 illustrates the average of 2.58 employees per patient bed, the highest was in Bait Hanoon hospital 4.62 employees per patient bed, and the lowest was in Dorra hospital 2.24 employee per patient bed. Comparing results with lavy (2006) research in Israeli hospitals had, on average, 2.86 employees per patient bed.

Table 4.5 Hospitals beds and employees numbers

| Hospital | No. of beds | No. of employees |
|---|---|---|
| **Shifa** | 619 | 1487 |
| **Dorra** | 91 | 197 |
| **Rantisi** | 47 | 173 |
| **Pediatric** | 132 | 311 |
| **Ophthalmic** | 40 | 109 |
| **Nasser complex** | 322 | 769 |
| **EGH** | 246 | 602 |
| **Al Aqsa** | 129 | 372 |
| **Al Najjar** | 80 | 247 |
| **Tal sultan** | 52 | 194 |
| **Kamal Odwan** | 103 | 310 |
| **Bait Hanoon** | 45 | 183 |

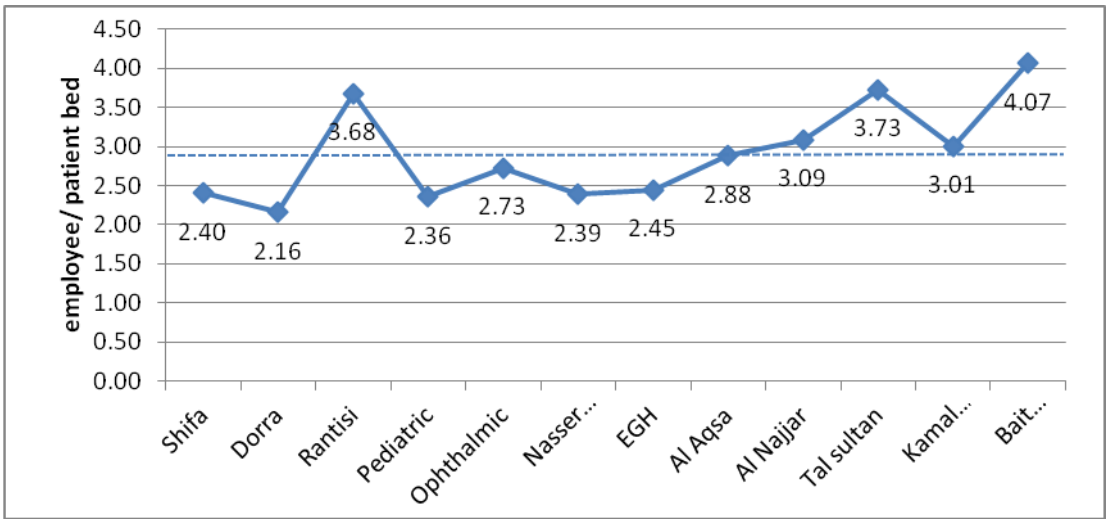



Figure 4.4 Number of employees vs. number of patient beds

**d) Maintenance employees**

As illustrated in the table 4.6 that the maximum number of technician staff on average is the electrical technician 5.8, 5.6 HVAC and 5.2 mechanic technicians. While in the engineer's staff, it was found that the biomedical engineers have the majority as 5 bio medical engineers on average for the center with a maximum total number of 16 biomedical engineers. The mechanical engineers come next with an average 2, next the electrical engineer come with an average 1.8 and finally the civil engineer which have the lowest staff numbers in maintenance center. Unfortunately there are no architect engineers in the maintenance department; this is due to two reasons: firstly the political situation in 2006 in Gaza Strip which led most of employees to leave their work. Secondly the maintenance and engineering department officers consider the scope of the architect works in maintenance field in MoH is limited, though they rely on the architects in department called "Engineering office". Lavy (2006) observed in 11 of the 12 acute care hospitals there is an average of 47.6 employees per healthcare facility, while in this research 63.2 maintenance employee per governorate because the employees distributed on the governorate maintenance center not on the hospital. As noticed there is difference between the two studies this is because of the incomplete data in Lavy (2006) study as he mentioned.

Figure 4.5 shows that 42% of the staff is located in Gaza governorate, because of the existence of 6 hospitals in Gaza city which is considered as the central for the entire maintenance center. Rafah center represents 25% of the maintenance staff due to the existence of European Gaza hospital which is considered as one of the most important hospital in the southern region.

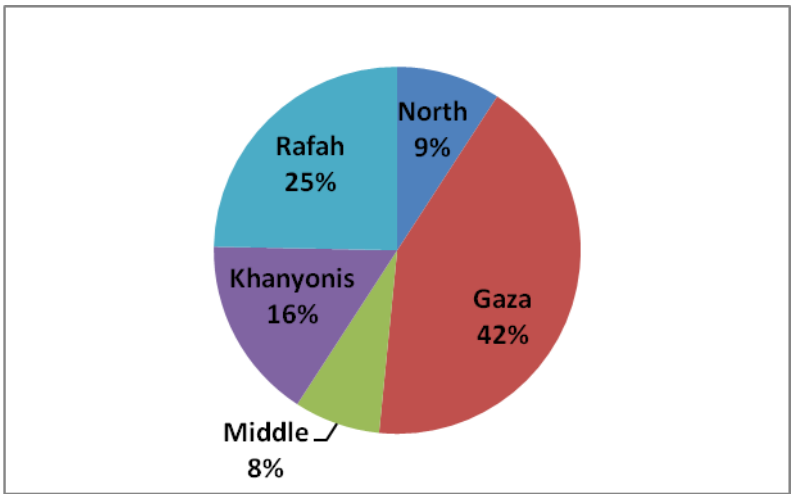



Figure 4.5 Maintenance employees allocation in Gaza Strip governorates

Table 4.6 Maintenance employee profession

| Profession | average | Min | Max |
|---|---|---|---|
| Head of Department | 1 | 1 | 1 |
| Administrative | 2.2 | 0 | 5 |
| Biomedical Engineers | 5 | 0 | 16 |
| Biomedical Technician | 4.4 | 0 | 14 |
| Civil Engineer | 1.4 | 1 | 3 |
| Civil Engineer assistant | .6 | 0 | 2 |
| Architecture Engineer | - | - | - |
| Electrical engineer | 1.8 | 1 | 4 |
| Electrical Technician | 5.8 | 0 | 15 |
| Mechanical Engineer | 2 | 1 | 3 |
| Mechanical Technician | 5.2 | 1 | 11 |
| Electro Mechanic Technicians | .6 | 0 | 3 |
| Plumping Technician | 3.4 | 1 | 6 |
| HVAC Technician | 5.6 | 2 | 15 |
| Sterilization Technician | 2.2 | 0 | 11 |
| Metal work | 4.4 | 2 | 12 |
| Painter | 2.4 | 0 | 8 |
| Carpenter | 4.8 | 2 | 12 |
| Communication Technician | 1.6 | 0 | 8 |
| Building Technician | 1.2 | 0 | 3 |
| Electronics Technician | 1.8 | 0 | 3 |
| Medical Gazes Technician | 0.2 | 0 | 1 |
| Aluminum Technician | 1.6 | 0 | 4 |
| Office devices Technician | 0.4 | 0 | 1 |
| Safety Technician | 0.2 | 0 | 1 |
| Water desalination Technician | 1 | 0 | 3 |
| Worker | 0.8 | 0 | 3 |
| Store officer | 0.4 | 0 | 2 |
| Maintenance technician | 1.2 | 0 | 3 |
| Total | 63.2 | | |

**e) Maintenance types**

As listed in the literature review that there are three main types of maintenance: preventive, corrective and immediate maintenance. The results indicated that all the 13 hospitals implement the corrective maintenance, the preventive maintenance done besides the corrective maintenance only in three hospitals: Rantisi hospital, European Gaza hospital and Tal El sultan. This is because it needs human recourses and more detailed plan and check list which is unavailable in the other hospitals. The immediate maintenance is existed in the real performance of the maintenance departments. But it in the results of the research its percentage was small because of the lack of documentation of the immediate requests.

**f) Maintenance expenditure**

Expenditure of maintenance in MOH hospitals categorized into two types:

(1) Internal sourcing which is funded from Ministry of Finance contains secondments, bills maintenance contracts and available space parts in MOH stores. Table 4.7 shows the sum of expenditure of building maintenance, spare parts, maintenance contracts and mechanical maintenance in 2011 and 2012 these data was driven from finance unit in MOH. There is another type of expenditure which is procurement orders some of these orders have been paid and involved in the internal sourcing and others not paid.

As noticed in figure 4.6 that there is a huge difference in local internal expenses of maintenance in hospitals. Shifa hospital has increased in 2012 about 22.5% than 2011, Rantisi hospital also increased about 73%, these increases are not systematic but its due to immediate maintenance items which are needed. On the other side other hospitals nearly stayed at the same level of expenses like; Naser pediatric, Al Najjar, Tal sultan and Bait Hanoon. The difference of expenditures in 2011 and 2012 would be reasoned for the starting of stabilization in the political status in the Gaza Strip and the support of Arabian countries for the budget of MoH.

(2) Outsourced funded are from international NGOs and Islamic bank which are presented in tables 4.8 and 4.9 , the donors for the maintenance projects have many conditions like choosing the target hospital to maintain, amount of donation and type of work done. Awarding the projects requires committees between the donors and MOH managers and engineers.

Table 4.7 Internal maintenance expenditure in 2011 and 2012

| Financial Year / Hospital | Maintenance expenditures 2011 NIS | Maintenance expenditures 2011 $ | Maintenance expenditures 2012 NIS | Maintenance expenditures 2012 $ |
|---|---|---|---|---|
| **Shifa** | 316361.91 | $ 85,503.22 | 661622.69 | $ 178,816.94 |
| **Dorra** | 13,327.71 | $ 3,602.08 | 82,355.50 | $ 22,258.24 |
| **Rantisi** | 441845.75 | $ 119,417.77 | 60865.34 | $ 16,450.09 |
| **Naser Pediatric** | 27045.4 | $ 7,309.57 | 75918.78 | $ 20,518.59 |
| **Ophthalmic** | 10626 | $ 2,871.89 | 26977.5 | $ 7,291.22 |
| **Nasser complex** | 332957.09 | $ 89,988.40 | 166286.75 | $ 44,942.36 |
| **EGH** | 319799.24 | $ 86,432.23 | 455402.75 | $ 123,081.82 |
| **Al Aqsa** | 66473.69 | $ 17,965.86 | 173525.7 | $ 46,898.84 |
| **Al Najjar** | 45525.14 | $ 12,304.09 | 77247.25 | $ 20,877.64 |
| **Tal sultan** | 23913.5 | $ 6,463.11 | 15049.5 | $ 4,067.43 |
| **kamal odwan** | 67105.03 | $ 18,136.49 | 194723.99 | $ 52,628.11 |
| **Bait Hanoon** | 15161.2 | $ 4,097.62 | 81794.43 | $ 22,106.60 |
| **Total** | 1,680,141.66 | $454,092.33 | 2,071,770.18 | $559,937.88 |

Table 4.8 Under implementation outsourced maintenance projects in 2012

| # | Project location | Funding organization | Value of donation in (US $) |
|---|---|---|---|
| 1 | Opthamtic rehabilitation and renovation | Islamic bank | $ 200,000.00 |
| 2 | Shifa , Naser Pediatric and kamal Odwan Hospitals maintenance | Islamic Bank for development | $2,876,000.00 |
| 3 | Dorra hospital maintenance | Muslim Hands | $ 80,000.00 |

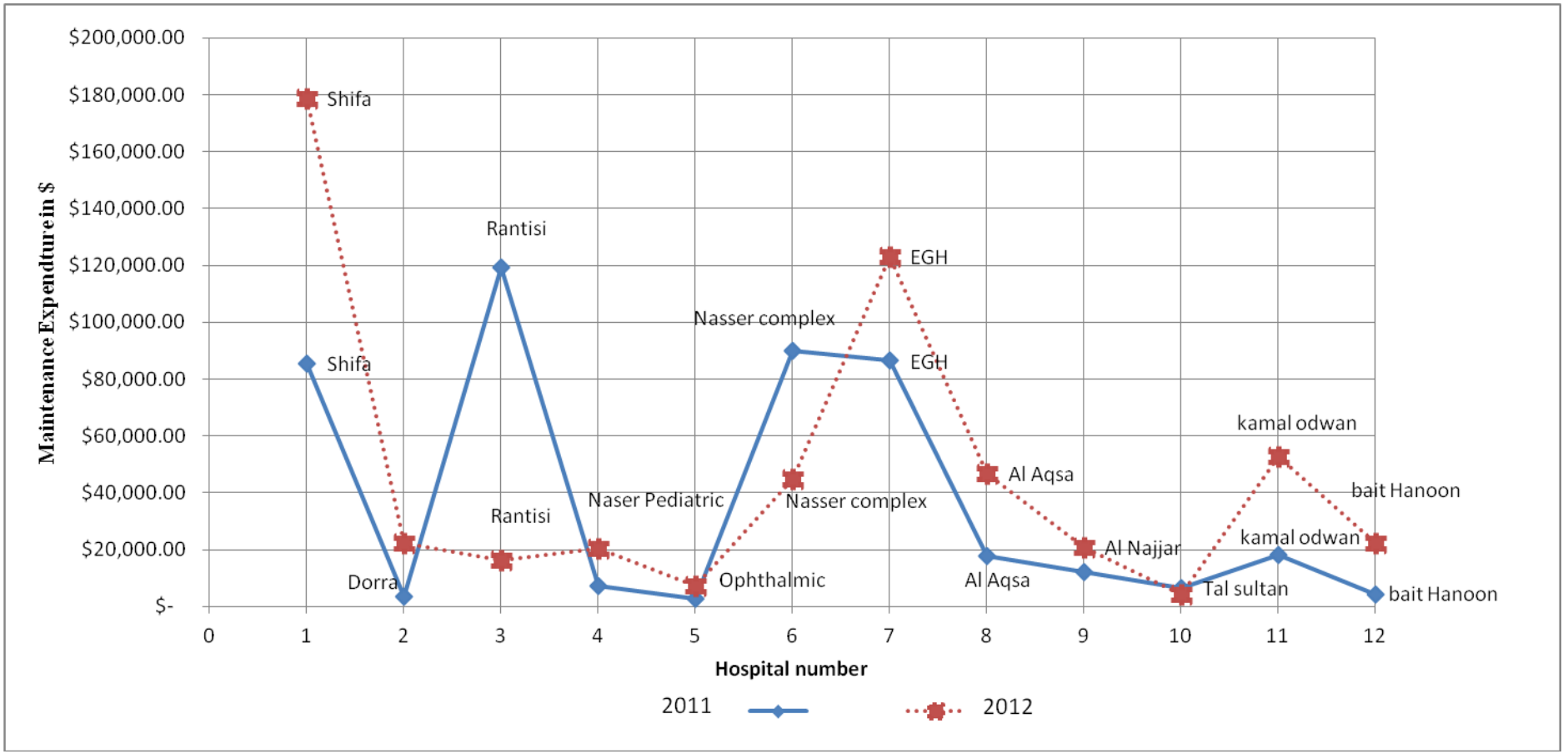



Figure 4.6 Internal sourcing of maintenance expenditure in 2011 and 2012 in MOH hospitals

Table 4.9 Implemented outsourced maintenance projects in 2012

| # | Project location | Funding organization | Value of donation in (US $) |
|---|---|---|---|
| 1 | Daily care department rehabilitation in Bait Hanoon hospital | International Arab Authority | $ 50,000.00 |
| 2 | Nasser complex | Islamic bank operated by Qatar Crescent | $910,348.00 |
| 3 | Nasser building maintenance in Nasser complex | Islamic Relief | $100,000.00 |
| 4 | Intensive care maintenance in Naser Pediatrics | Islamic bank operated by Qatar Crescent | $200,000.00 |
| 5 | Operation room maintenance in Kamak Odwan hospital | Islamic Relief | $ 20,000.00 |

### 4.2.2 Functional management service delivery of maintenance aspects

This aspect covers the management service delivery attributes or the service profiles that the management holds in maintenance departments.

**a. Responsiveness and timeliness**

The results indicated that 50% of the maintenance departments took few hours to respond to maintenance requests, while the rest take one day to respond for the normal requests .There is a good coordination of receiving the requests from the hospitals users. While the problem which occurs in implementing the request which is connected with the availability of spare parts and the adequate technicians.

**b. Delivering characteristics**

92.3% of the respondents described that the building conditions in the hospital improved from year to year concerning maintenance improvements. 83.3 % mentioned that the final situation of the maintained building is getting better, while 16% stated that it is the same no variance in building conditions.

These results showed that how the recently rapid movements of maintenance projects done in hospitals buildings started to give a big effect in improving the building situation.

**c. Relevance**

The finding of this study showed that 69.2 % of the maintenance department`s received maintenance requests are related to the existing complaint, while 30.8 % no relation

between the maintenance request and the actual need for maintenance. This is due of shortage of training the users of hospital facility on how to request the maintenance.

Nik Mat et al (2011) researched the priorities of service characteristics set by end users and maintenance managers which results that they are in contradiction with each other. Survey results have shown that the end users have chosen reliability as the first and foremost priority in service characteristics followed by responsiveness and assurance. Similarly, all maintenance managers have positioned the said service characteristics as their top three priorities in maintaining a building with a slightly different priority order.

### 4.2.3 Maintenance department's activities

Starting with having a written long-range plan for building maintenance and repairs that extends out a minimum of three to five years about 76.9% was having the written plan which in real represents the annual needs for the maintenance department as corrective not the preventive maintenance requirements. This is due to inexistence of scheduled check lists in all the governmental hospitals.

#### 4.2.3.1 **Inspection interval of civil works activities frequency**

The frequencies in the survey indicate that 61.5 % of maintenance departments have no routine inspection of plumbing and water system occurs. The inspection done only when there is a problem in the water and sewage networks. However 84.6% of maintenance departments replacement of worn washers and defective plugs which is part of the corrective maintenance procedures.

Table 4.10 listed the main works in the buildings and their periodic frequencies; the electrical renewing is the most frequented activity which is average about 35 times monthly, while roof maintenance is the most frequented 8 times yearly. Water and sewage networks have less attention which is once a year on average. These results indicate that a preventive maintenance should be existed to increase the attention to all the main systems in the building to prevent sudden failure in these systems.

Table 4.10 Periodic frequencies of civil works

| **Activities** | **Period (week, month, year)** | | | | | |
|---|---|---|---|---|---|---|
| | Week | | Month | | Year | |
| | N | % | N | % | N | % |
| Painting and washing down | 1 | 11.1 | 3 | 33.3 | 5 | 55.6 |
| Road and pathways repaired | * | * | * | * | 1 | 100.0 |
| Drainage and sewage work performed | * | * | 1 | 33.3 | 2 | 66.7 |
| Water networks | 1 | 16.7 | 3 | 50.0 | 2 | 33.3 |
| Roof and gutter maintenance performed | * | * | 1 | 11.1 | 8 | 88.9 |
| Floors finished | * | * | * | * | 7 | 100.0 |
| Electrical renewing | 10 | 20.0 | 35 | 70.0 | 5 | 10.0 |
| Other: replacement of sinks, shelves, windows and doors | 1 | 10.0 | 2 | 20.0 | 7 | 70.0 |

* No answer

#### 4.2.3.2 Medical equipments maintenance procedure

Table 4.11 summarized the general procedures for the medical equipments maintenance. 69.2% of hospitals have no maintenance plan for the medical equipment which include scheduled inspections and routine checkup, while 92% of the hospitals have the master record which identify each equipment location, number and the users of the equipment. Due to the high priority for the medical equipment in the Gaza strip hospitals 53.8% of hospitals have action record for the medical equipment. The hospitals make the action record through computerized system which contains the location of the device, the person responsible on it and when it was maintained. For the mechanical systems like ventilators and gazes station there is a good follow up for their status about 76.9% of hospitals make the routine inspection for the mechanical systems. These results match in line with Mutia et al (2012) research which concluded that the performance of scheduled preventive maintenance services on the medical equipment does not take priority over corrective repairs in most of the public hospitals compared to private hospitals. Public hospitals have no quality control system for the repair and preventive maintenance. Technical manuals are not fully utilized when repairs are made, maintenance on the medical equipment are not done on the stipulated time frame. Deferment of maintenance may be required due to non-availability of manpower or other extenuating circumstance for instance lack of spare parts.

Table 4.11 Medical equipment maintenance

| **Activities** | Yes | | No | |
|---|---|---|---|---|
| | N | % | N | % |
| hospital have maintenance plan for equipment | 4 | 30.8 | 9 | 69.2 |
| The maintenance manuals for hospital equipment are in one location | 9 | 69.2 | 4 | 30.8 |
| master record of maintenance for each piece of equipment in the hospital | 12 | 92.3 | 1 | 7.7 |
| action record that details the scheduled maintenance to be performed for each piece of equipment on a regular basis or schedule | 7 | 53.8 | 6 | 46.2 |
| routine inspections, oiling and replacement of defective parts for mechanical systems. | 10 | 76.9 | 3 | 23.1 |

## 4.3 *Second objective*: Determine factors affecting maintenance management of public hospital buildings.

### 4.3.3 Problems that hospitals face in building maintenance

There are most common 7 problems that the hospitals buildings maintenance may face. Table 4.12 shows that there are three main problems found in the hospital building maintenance was not enough staff, not enough money and poor contractors performance on buildings. In the others category the misuse of health facilities from patient`s attendants who steeled many items especially in sanitation facilities and ruin the furniture in the buildings. Cooper and Jones (2008) showed their results breakdown of the building maintenance problems. A lack of money was by far the biggest problem being faced. The next biggest issue was building design then service administration inefficiencies, too many calls and poor contractor performance.

Table 4.12 Hospital building maintenance problems

| Response | N | Percent |
|---|---|---|
| Not enough staff | 13 | 100.0% |
| Building design inefficiencies | 9 | 69.2% |
| Too many calls for service | 9 | 69.2% |
| Service administration inefficiencies | 3 | 23.1% |
| Not enough money | 10 | 76.9% |
| Poor construction quality | 7 | 53.8% |
| Poor contractor performance | 11 | 84.6% |
| Other(misuse, lack of staff development) | 2 | 15.4% |
| Total | 64* | 100.0% |

*There are multiple responses

### 4.3.4 Major sources of maintenance related complaints

Table 4.13 represents that the cleaning attitude in the hospitals facilities is the major source of complains. All the 13 (100%) hospitals complained from the cleaning issues which have led to serious problems in the structure of the buildings which led to wet and moisture in the walls ceilings and floors. Plumping, water supply and waste disposal each one represents 76.9% of complains. Also the building design issues which represents 38.5%, this emphasizes one of the drawbacks to the traditional way of designing and developing new buildings which does not incorporate early input from the maintenance department.

In Gaza Strip most of the building design didn't took the maintenance in consideration. In Cooper and Jones (2008) research which focused on housing maintenance, the most complaints were for repair/replace, followed by plumbing. The reason of all hospitals in Gaza Strip complained from the cleaning issues, that cleaning is done by outsourced companies or contractors. The cleaning companies' staff didn't receive special training or orientation.

Table 4.13 Sources of maintenance complains

| Complaints | N | Percent |
|---|---|---|
| Cleaning | 13 | 100.0% |
| Indoor Air Quality | 1 | 7.7% |
| Plumbing | 10 | 76.9% |
| Choice of Materials | 8 | 61.5% |
| Repair/Replace | 5 | 38.5% |
| Heat Loss/Gain | 1 | 7.7% |
| Storage | 2 | 15.4% |
| Medical Equipment | 10 | 76.9% |
| Waste Disposal | 10 | 76.9% |
| Fire Protection | 2 | 15.4% |
| Sound Penetration | 0 | 0 |
| Design | 5 | 38.5% |
| Water Supply | 11 | 84.6% |
| Telecommunications | 1 | 7.7% |
| Lighting | 8 | 61.5% |
| Other | 2 | 15.4% |
| Total | 89* *There are multiple responses | |

### 4.3.5Major cause of non maintenance of hospital building

Ranking information for the causes of non maintenance in hospital building are outlined in tables 4.14 and table 4.15 outlined the final arrangement for the ranking. From the tables it can be found that the first place is the lack of maintenance culture either from users or patients. This problem needs a comprehensive awareness from the management to distribute it on all the levels of the people using the health facilities medical staff, patients, administrative, cleaning workers and the visitors of the hospitals. The second place is the inadequate fund which limits the maintenance activities for the important priorities only. Blockade on Gaza Strip and restriction on the movement of goods was in the third place and the fourth place Poor work done on building is resulting from it; by having low quality materials and unavailability of wide collection of materials to choose the best of them.

This results differs from Cooper and Jones (2008) results inadequate fund was the biggest problem being faced. The next biggest cause bureaucratic reporting process. However Cobbinah (2010) results match that lack of maintenance culture is the main cause. In summary it was obvious that the culture of maintenance is almost absent in our community, and not surprising that it is the first cause of non maintaining the hospital buildings.

Table 4.14 Ranking of causes of non maintenance of hospital buildings

| **Causes of non maintenance of hospital buildings** | **Rank** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| Blockade on Gaza Strip and restriction on the movement of goods | 2 | 1 | 5 | - | 1 | 1 | 3 |
| Lack of maintenance culture | 7 | 2 | 1 | - | 2 | - | 1 |
| Inadequate funds | | 6 | 3 | - | 1 | 2 | 1 |
| Bureaucratic reporting process | 1 | 2 | - | 1 | 3 | 4 | 2 |
| Pressure on facility/building due to number of occupants | 2 | 2 | 3 | 5 | - | 1 | - |
| Poor work done on building | - | - | 1 | 7 | 5 | - | - |
| Non response to maintenance request | - | - | - | - | 1 | 5 | 7 |

Table 4.15 Arranged ranking of causes of non maintenance of hospital building

| **Causes of non maintenance of hospital buildings** | Final Rank |
|---|---|
| Lack of maintenance culture | 1 |
| Inadequate funds | 2 |
| Blockade on Gaza Strip and restriction on the movement of goods | 3 |
| Poor work done on building | 4 |
| Bureaucratic reporting process | 5 |
| Pressure on facility/building due to number of occupants | 6 |
| Non response to maintenance request | 7 |

### 4.3.6 Maintenance Staff skills and behavior

The results indicated that:

84.6% of the maintenance departments strategy was to collect historical data for the identification of maintenance trends. Cooper and Jones (2008) stated that 80% of their research respondent collected historical data to identify maintenance trends.

Level of motivation for maintenance staff by the management was low with 61.5% percentage. This indicates the staff works without encouragements for development and without competition. While 23.1% mentioned that there is an average motivation. Unlike Adengua et al (2007) the result indicated average level of motivation for maintenance staff with 39.7% as rated by the maintenance staff.

The causes of low motivation of maintenance staff listed in table 4.16. The main cause was the poor pay with 69.2% this is due to the lack of bounces awards and the absence of a law which supports the motivation system. Lacks of opportunities for training/development and unhealthy working condition have got 61.5% as cause of low motivation. In the Gaza Strip hospitals the dependence on the staff past experience, there is no development of the quality of work depending on standards.

Table 4.16 Low motivation causes for hospitals maintenance staff

| Causes | N | Percent |
|---|---|---|
| Lack of working tools/ equipment/materials | 2 | 15.4% |
| Irregular payment of salaries | 1 | 7.7% |
| Delayed promotion | 5 | 38.5% |
| Poor pay | 9 | 69.2% |
| Lack of opportunities for training/development | 8 | 61.5% |
| Job insecurity Unsafe/unhealthy working condition | 8 | 61.5% |
| Total | 33 | |

Unlike Adengua et al (2007) who stated that 50.7% of the respondents rated lack of working tools/equipment/materials as a cause of low motivation in executing the maintenance programmes in public hospitals.

76.9% of maintenance departments have no training programme for users on how to effectively manage the facilities within the hospital buildings. This is an indication of poor orientation of training from the management side . Adengua et al (2007) have approximate results with 61.8% of no training for users to manage the facilities within the hospitals buildings

All the training type given by the management to the staff of Maintenance department was in service training with about 92.3%. While 7.7% of the training types was do it yourself.

Unlike Adengua et al (2007) who stated that 55.9% of the training type was user's guide distributed for reading. This reflects that the hospital have its standards and written in a user guide for all the staff.

53.8% of maintenance departments stated that their engineers and managers received training to conduct the condition assessments of the hospital buildings.

Satisfaction levels in maintenance departments from the outsourced maintenance projects were 69.2% good and 23.1% fair with the performance of the outsourced projects.

### 4.3.7 Test of Normality for Total area, Total Number of beds, Acute-care hospitalization and Day-care hospitalization distribution

Table 4.17 shows the results for Shapiro-Wilk test of normality. From Table 4.15, the p-value for each variable is smaller than 0.05 level of significance and then the distributions for these variables *are not normally distributed*. Consequently, Spearman correlation coefficient is used to examine the relationship between total area and each of total number of beds, acute-care hospitalization beds, and day-care hospitalization beds.

Table 4.17 Shapiro-Wilk Test of Normality

| Variables | Shapiro-Wilk | | |
|---|---|---|---|
| | **Statistic** | **Df** | **P-value** |
| Total area | 0.569 | 10 | 0.000* |
| Total Number of beds | 0.745 | 10 | 0.003* |
| Acute-care hospitalization beds | 0.694 | 10 | 0.001* |
| Day-care hospitalization beds | 0.658 | 10 | 0.000* |

* The distribution is not normally distributed at 0.05 level |df: Degrees of freedom

Table 4.18 shows the following results:

- The correlation coefficient between total area and total number of beds equals 0.542 and the p-value (Sig.) equals 0.028. The P-value (Sig.) is less than 0.05, concluding that there exists significant positive relationship between total area and total number of beds. Which means that the number of beds increase due to the increase in the total are of the hospital.
- The correlation coefficient between total area and acute-care hospitalization equals 0.554 and the p-value (Sig.) equals 0.031. The P-value (Sig.) is less than 0.05, then we conclude there exists significant positive relationship between total area and acute-care hospitalization beds. Which means that the number of acute-care hospitalization beds increase due to the increase in the total are of the hospital.
- The correlation coefficient between total area and day-care hospitalization equals 0.700 and the p-value (Sig.) equals 0.008. The P-value (Sig.) is less than 0.05, then we conclude there exists significant positive relationship between total area and day-care hospitalization beds. This means that the number of day -

care hospitalization beds increase due to the increase in the total are of the hospital.

Table4.18 Correlation coefficient between total area and each of total number of beds, acute-care hospitalization beds, and day-care hospitalization beds

| No. | Item | Spearman Correlation Coefficient | P-Value (Sig.) |
|---|---|---|---|
| **1.** | Total Number of beds | .542 | **0.028*** |
| **2.** | Acute-care hospitalization | .554 | **0.031*** |
| **3.** | **Day-care hospitalization** | **.700** | **0.008*** |

* Correlation is significant at the 0.05 level

### 4.3.8 Relationship between pressures on facility building due to number of occupants, number of beds and total area of the hospitals in the Gaza Strip

- In table 4.19 the spearman correlation coefficient between pressure on facility/building due to number of occupants and total area equals -0.103 and the p-value (Sig.) equals 0.369. The P-value (Sig.) is greater than 0.05, then we conclude there exists insignificant negative relationship between Pressure on facility/building due to number of occupants and Total area. This means that there is a slight correlation between the pressure on the facility and the total area of the hospital.
- The correlation coefficient between pressure on facility/building due to number of occupants and Total Number of beds equals -0.040 and the p-value (Sig.) equals 0.448. The P-value (Sig.) is greater than 0.05, then we conclude there exists insignificant negative relationship between Pressure on facility/building due to number of occupants and total number of beds. This means that There is a slight negative correlation between the number of beds and total area of the hospital.

Table 4.19 Correlation coefficient between pressure on facility/building due to number of occupants and total area of hospitals

| No. | Item | Spearman Correlation Coefficient | P-Value(Sig.) |
|---|---|---|---|
| **1.** | Total area | -0.103 | **0.369** |
| **2.** | **Total Number of beds** | **-0.040** | **0.448** |

Table 4.20 shows that p-value (Sig.) equals 0.811 which is greater than the level of significance $\alpha = 0.05$, then there is insignificant difference among the respondents toward lack of maintenance culture due to training programme for users on how to effectively manage the facilities within the hospital buildings.

This illustrates the poor orientation on the part of management to train the users results of lack of maintenance culture.

Table 4.20 Mann-Whitney test and p-value for training programme for users

| Item | Response | Mean Rank | P-value(Sig.) |
|---|---|---|---|
| **There are training programme for users on how to effectively manage the facilities within the hospital buildings** | Yes | 6.50 | **0.811** |
| | **No** | **7.15** | |

## 4.4 *Third objective*: Maintenance performance indicators results in the Gaza Strip hospitals

Applying equations in section 3.10.1.1, the building performance indicator was calculated and the mean scores for the buildings system are showed in table 4.19. The standard deviation also represented to shows how much variation exists from the average value. The highest standard deviation was in the structure system because of some hospitals recently renovated which gives maximum scores for some buildings scores. The next highest standard deviation was in fire protection and the reason is some hospitals do not operate the fire alarm system and if it exists the detector is not active. This results of low performance scores. In conclusion for the average values for the surveyed buildings performance structure, interior finishes, sanitary, HAVC, and elevators systems were in *Marginal condition* some preventive maintenance measures must be taken. While exterior envelope, electrical, fire protection, communications and medical gases systems were found in *Good condition*.

Maximum and minimum performance scores for the 21 building also showed in table 4.21. These high maximum for the system performance can be explained to the outsourced rehabilitation projects which in its role have made a noticeable change.

Table 4.21 Summary of the building system performance scores

| **Building component** | **Sample size** | **Performance scores** | | | |
|---|---|---|---|---|---|
| | | **average** | **max** | **min** | **S.D** |
| Structure | 21 | 79.44 | 93.3 | 50 | 13.77565 |
| Exterior Envelope | 21 | 83.19 | 96.6 | 66.6 | 8.185349 |
| Interior finishes | 21 | 78.05 | 94 | 68 | 8.458583 |
| Electricity | 21 | 85.17 | 96.6 | 71.5 | 6.224781 |
| Sanitary system | 21 | 70.71 | 82.5 | 45 | 9.878729 |
| HVAC | 18 | 76.11 | 100 | 60 | 9.164438 |
| Fire protection | 21 | 82.42 | 100 | 46 | 11.37607 |
| Elevators | 17 | 76.47 | 90 | 40 | 11.16297 |
| Communications | 21 | 80.71 | 90 | 70 | 5.542047 |
| Medical gases | 19 | 85.39 | 100 | 80 | 7.649581 |
| BPI | 21 | 76.18 | 85.26 | 70 | 4.817625 |

Seven of the surveyed hospitals buildings have got better attention from donors, due to the available fund and the need assessment that MoH determined. Starting with the higher performance values electricity and medical gazes systems which is a dangerous and vital system in healthcare building, maintenance staff makes sure that all the components should be in perfect performance. HAVC system in the recent two years have been improved in the main hospitals, otherwise in others is neglected like Psychiatric and Tal Sultan hospitals.

Table 4.22 gives the whole variables needed to measure the performance of the maintenance. These data was collected from the survey on the buildings and MOH financial unit, hospital general directorate and maintenance engineering directorate. Table 4.20 shows all the needed variables to calculate: annual maintenance expenditure (AME) $US/ sq. m and maintenance efficiency indicator (MEI). However age coefficient (AC) from table 3.5 and the occupancy coefficient from Appendix C.

### 4.4.1 Analysis of calculated KPIs

#### 4.4.1.1 Building performance indicator (BPI)

As showed in figure 4.7 that higheest BPI is 81.66 which is in European Gaza Hospital and this is in good condition. While the lowest score was for Dorra hospital 69.05 and Opthalmic hospital 68.26 which reflected deterioration of the building. Therefore, preventive maintenance activities must be carried out. In these two hospitals sanitary systems replacement of water supply installation and of sanitary accessories are primarily required; and interior finishes replacement of interior doors, paintings and ceramic tiles in bathrooms are required.

Table 4.22 Needed variables for KPIs calculation

| | Shifa | Dorra | Rantisi | Naser Pediatric | Ophtha -lmic | Nasser complex | EGH | Al Aqsa | Al Najjar | Tal sultan | kamal odwan | bait Hanoon |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total number of patient beds in the surveyed building** | 273 | 91 | 51 | 136 | 42 | 322 | 261 | 136 | 80 | 52 | 104 | 45 |
| **Occupancy no. of bed per 1000 sq m** | 61.90 | 113.75 | 25.50 | 68.00 | 44.68 | 89.44 | 43.50 | 75.56 | 45.71 | 65.00 | 50.00 | 45.00 |
| **Total Annual Maintenance Expenditure [$US]2012** | 40,000.00 | 3,631.53 | 16,450.09 | 20,518.59 | 7,291.22 | 44,942.36 | 123,081.82 | 46,898.84 | 20,877.64 | 4,067.43 | 52,628.11 | 22,106.60 |
| **Annual Maintenance Expenditure $US /m2 2012** | 9.07 | 4.54 | 8.23 | 10.26 | 7.76 | 12.48 | 20.51 | 26.05 | 11.93 | 5.08 | 25.30 | 22.11 |
| **AMEPB 2012** | 146.52 | 39.91 | 322.55 | 150.87 | 173.60 | 139.57 | 471.58 | 344.84 | 260.97 | 78.22 | 506.04 | 491.26 |
| **Building Performance Indicator 2012** | 70.90 | 69.05 | 77.51 | 80.32 | 68.26 | 74.19 | 81.66 | 80.53 | 73.09 | 77.62 | 77.50 | 78.20 |
| **Age Coeff.** | 1.33 | 0.808 | 0.598 | 1.05 | 1.012 | 1.05 | 0.808 | 0.808 | 0.622 | 0.598 | 0.785 | 0.622 |
| **Occupancy Coeff.** | 1.4515 | 0.7181 | 0.6316 | 1.1368 | 1.3352 | 1.1368 | 0.7181 | 0.7181 | 0.7122 | 0.6316 | 0.737 | 0.7122 |
| **Maintenance Efficiency Indicator 2012** | 0.08 | 0.11 | 0.28 | 0.11 | 0.08 | 0.14 | 0.43 | 0.56 | 0.37 | 0.17 | 0.56 | 0.64 |

Comparing the results with Lavy (2006) which his field survey that was carried out in 2001. The total average performance score of the BPI was found to be 76.6 points. This means that the level of performance of facilities in this survey was satisfactory. These results come in line with this research for 21 building of 13 hospitals. The BPI was for total average performance 76.18 which is marginal status due to the ranges mentioned in section 3.10.1.

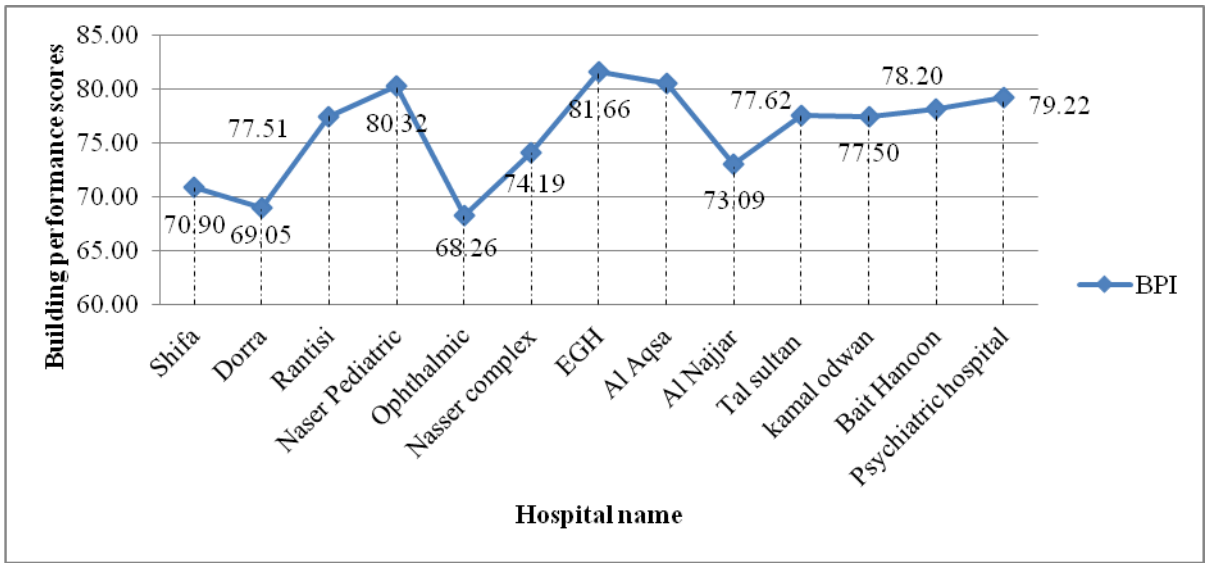



Figure 4.7 BPI results for Gaza strip hospitals

### 4.4.1.2 Annual maintenance expenditure (AME)

A hospital maintained at optimal level, it is expected that an annual maintenance expenditure of $54.2 per sq m (Shohet et al, 2003). As shown in figure 4.8 that all hospitals with average of $13.8 per sq m. These results were under the standard level of expenditure; this is due the limited sources of hospital funding and the poor financial statement for the MOH.

In Lavy (2006) the analyses of 2001 field survey showed the total annual maintenance expenditure $25.6 per sq-m. It's obvious the big difference of the expenditure in the Palestinian and Israelis hospitals. Palestinian hospitals in the Gaza Strip are less than about the half of the Israeli expenditure comparing the years that the researches were done. It seems that the health expenditure in Gaza Strip is lags far behind.

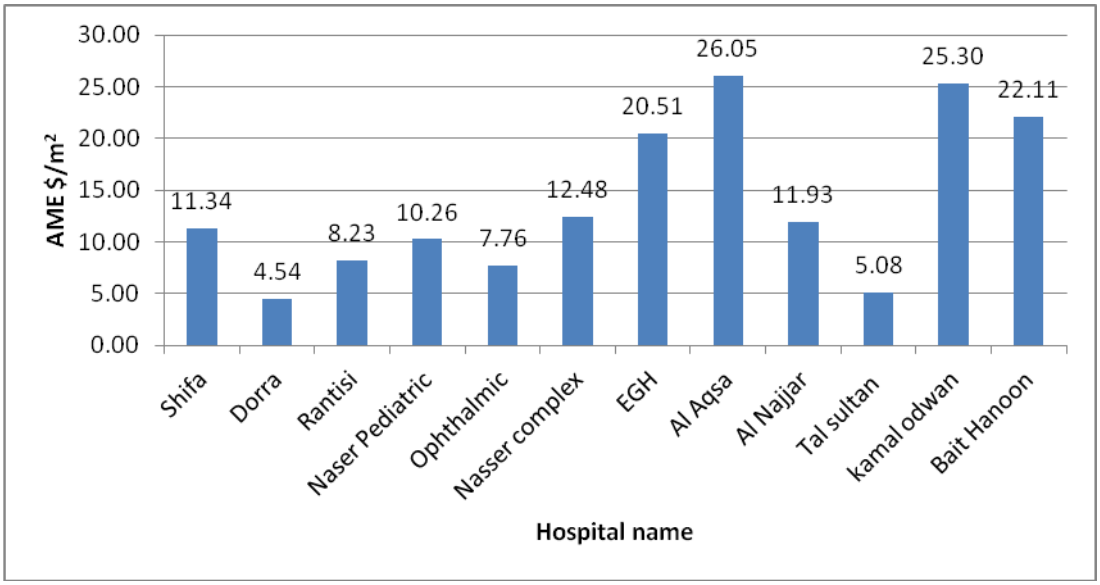



Figure 4.8 Annual maintenance expenditure in 2012 US dollar per sq. m

### 4.4.1.3 Maintenance efficiency indicator (MEI)

The MEI provides a quantitative indication of the spending efficiency of the available resources. As explained in section 3.10.1.3 there were limits for the MEI values between 0.37 and 0.52. Figure 4.9 presents that Al najjar, European Gaza Hospital and Al Aqsa represents the desirable situation for a maintenance department, indicating reasonable use of maintenance resources.

In the other side Shifa, Dorra, Rantisi, Naser Pediatrics, Naser complex, Tal sultan and Opthalmic hospital represents represent a state of low budgetary. In average the MEI for Gaza hospitals was 0.3 which indicated low budgetary investment. In Lavy (2006) the analyses of 2001 field survey showed that the Maintenance Efficiency Indicator was 0.514 – nearby to the value of 0.52, meaning that the maintenance expenditure is high in comparison with the actual performance. While Shohet et al (2003) results showed that the average MEI was found to be 0.44, a value that reflects an efficient use of resources considering the relatively low level of expenditure on maintenance

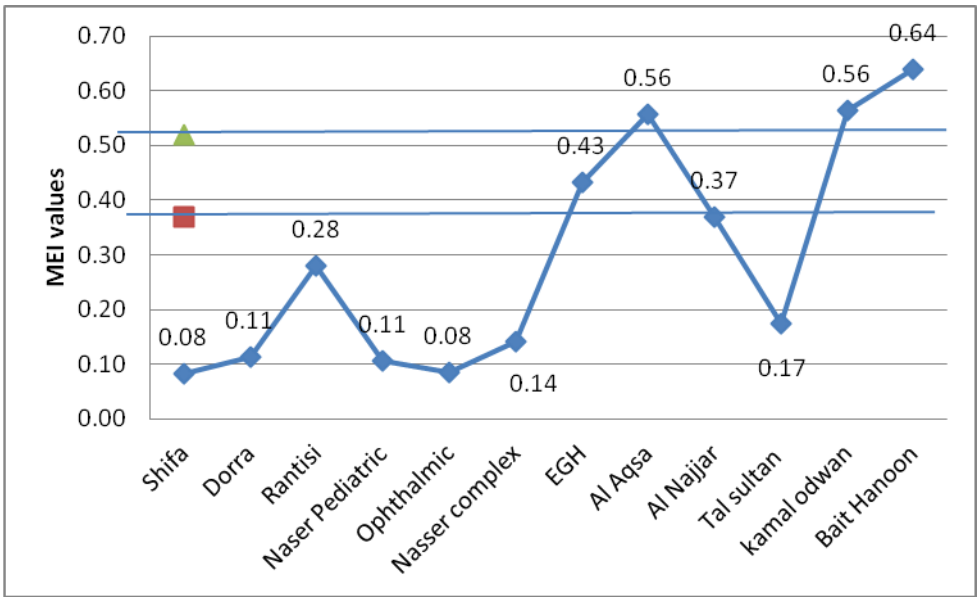



Figure 4.9Maintenance efficiency indicator MEI

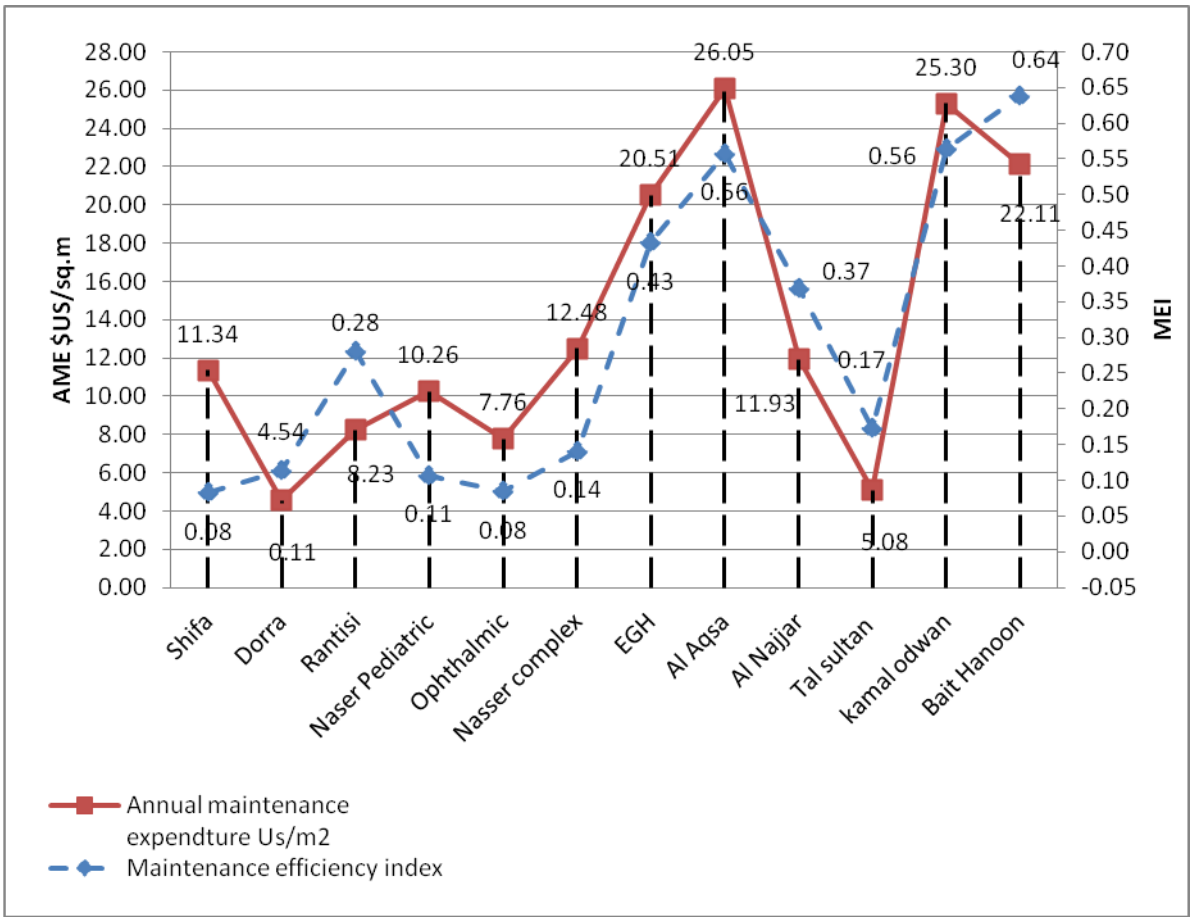



Figure 4.10 Relations between MEI and AME KPIs

Figure 4.10 represents a positive relationship between MEI and AME i.e. in EGH the MEI = 0.43 which is indicates reasonable use of maintenance resources the AME = 20.51 $ per meter square. These results indicated a start of good indication about the maintenance expenditure. For Shifa hospital the AME must be increased because it reflects low budget which indicates directly in the MEI which equals 0.08 which represents low budgetary investment.

### 4.4.1.4 Urgent repair indicator (URI)

A high value of URI means that the engineering staffs are heavily engaged in urgent repairs, being distracted from carrying out normal corrective and preventive works. The results indicated that the maximum urgent request in 2012 was 1000 request see appendix D for sample for maintenance requests). The numbers of the urgent requests was not accurate due to the

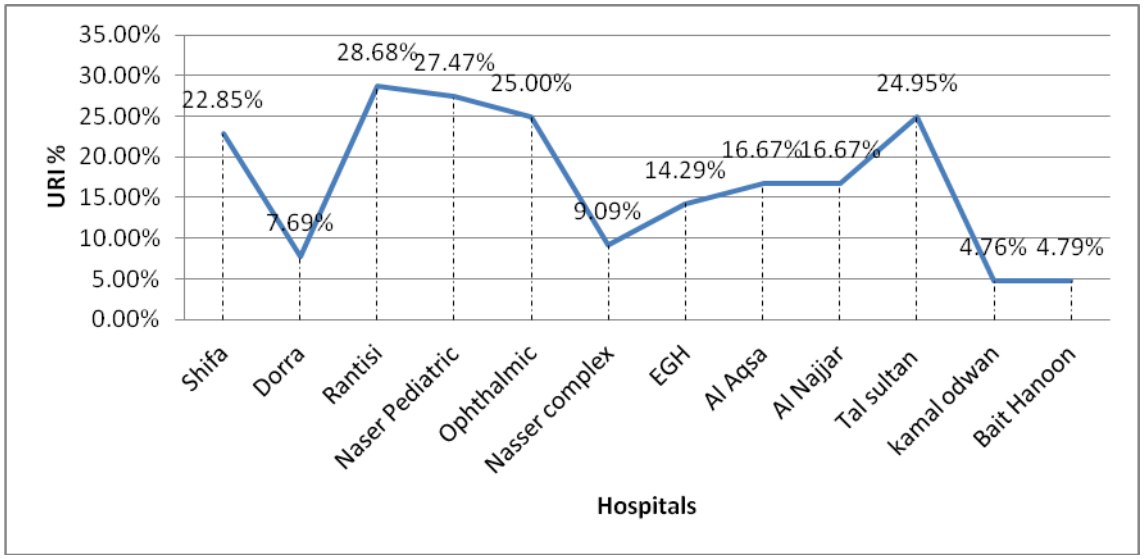



Figure 4.11 Urgent repair indicator graph

lack of documentation. The numbers was taken as percentages from the general requests as the manager of the maintenance department evaluated. Almost URI percents in figure 4.11 considered as an average percent**.** This means the engineering staff are moderately engaged in urgent repairs.

### 4.4.1.5 Comparisons between Occupied Palestinian Territories (Israel)and Gaza strip

As noticed from the literature review that Shohet (2003) has developed the key performance indicators to be adequate for hospital maintenance as a facility management measures. From the results taken from the research of Shohet et al (2003), the comparison was represented in table 4.23 and figure 4.12.

Table 4.23 KPIs comparison between Occupied Palestinian Territories (Israel)and Gaza strip hospitals

| KPIs | Occupied Palestinian Territories (Israel)hospitals | Gaza strip hospitals |
|---|---|---|
| **Research Year** | 2003 | 2012 |
| **Number of hospitals** | 17 | 13 |
| **BPI(building performance indicator)** | 68.8 | 76.18 |
| **AME (annual maintenance expenditure)$US/sq.m** | 37.2 | 13.8 |
| **MEI (maintenance efficiency indicator)** | 0.44 | 0.3 |
| **MSC (managerial span of control) Maintenance manager employee** | 3.5 | 1 |

The average of BPI for Gaza hospitals is higher the Israeli because of the recent rapid maintenance projects. In 2011 and 2012 which improved the performance of the buildings. The annual maintenance expenditure in Occupied Palestinian Territories (Israel) is higher 2.5 times than in the Gaza due to the excellent financial status in the Israeli hospitals. In Occupied Palestinian Territories (Israel)there were about 3 Maintenance manager employees per health facility, while in the Gaza Strip hospitals there were only 1 per hospital. This reflects the variance of maintenance management in the two territories. Culture, political status and financial statements considered factors that affected the measurements of KPIs in Gaza Strip hospitals.

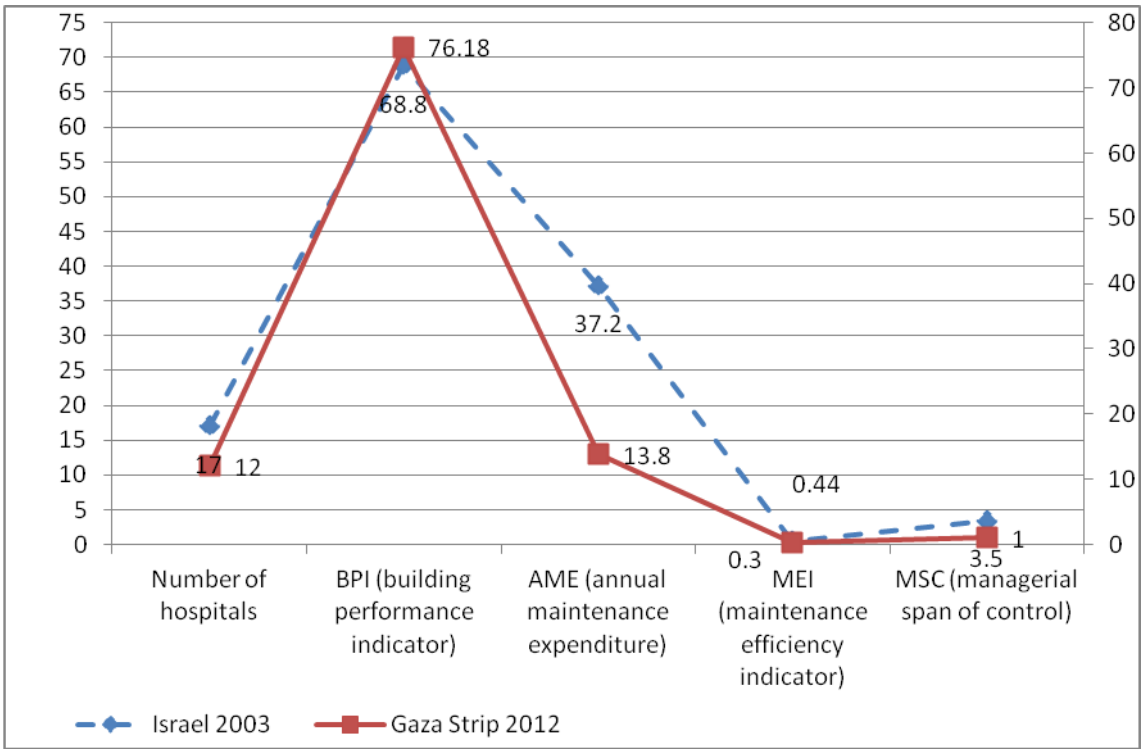



Figure 4.12 KPIs comparison between Occupied Palestinian Territories (Israel)and Gaza strip hospitals

When comparing with WHO (2010) report it will be found that most of the hospital buildings were in a reasonable physical condition, better than might be expected after almost 5 years of siege. The physical condition of 8 of the 13 hospitals was rated "good". The condition of just 4 hospitals was rated poor, as an average score. In 5 hospitals, however, some buildings (or parts of them) need replacing. The most frequent problems identified were the absence or very poor condition of fire protection system (in 11 hospitals) and the fact that elevators were not available or not functioning (in 5 hospitals). Most hospitals need substantial refurbishment of the interior to improve their appearance.

These results come in line with finding of this research, no conflict found between the results.

# 4.5 Case studies

### 4.5.1 No. 1: obstetric and gynecology hospital building (second floor) in Shifa hospital corrective maintenance

### 4.5.2 Introduction

Al-Shifa hospital is the biggest medical institution in the Palestinian ministry of health. It is considered secondary health care delivery system and provides some tertiary care services for population. It's located in the west part of Gaza. The hospital was established in 1946 on an area of over 45.000m.sq. and it was developed over the years until now. Many buildings were built like radiotherapy department, burn department, special surgery department, second floor in internal medicine department. Till 2012 the hospital contained 590 hospitalization beds, distributed in internal medicine, general and specific surgeries, burn intensive care, obstetric and gynecology and neonatal department.

AL-Shifa hospital is subdivided into 3 hospitals as surgical hospital, medical hospital and obstetric and gynecology hospital beside paramedical services such as Laboratory, Radiotherapy, Pharmacy, and Physiotherapy. Each hospital has its own administrative team and each manager refer to his general director of hospital (Ministry of health annual report, 2010).

### 4.5.3 Project description

- Project Name: Maintenance of Second floor in Obstetric and gynecology hospital building
- Location: Shifa hospital- Gaza city
- Project Value: $ 100,000.000
- Owner: MOH
- Donor: Islamic Bank for development

### 4.5.4 Problem identification

Obstetric and gynecology hospital considered as one of the most buildings in Shifa complex for its daily importance for Palestinian women. According to MOH report more than 21,000 babies have been born by the end of 2011 in

Gaza city only. This number indicates the increase of demand on obstetric medical services in Shifa hospital. The old age building, high occupancy of patients and lack of periodic maintenance resulted in many problems in the building figures 4.13 and 4.14 illustrates wide range of wet areas in walls and ceilings.

Figure 4.13. Wet areas in walls and ceilings problems in Shifa hospital

Figure 4.14 Wet areas problems in floors and walls.

Staff in engineering and maintenance department examined the place and found the main problems in hospital building:

- Old age,
- Number of toilets per floor.
- Tile de bonding
- Staining of tiles,
- Staining of ceiling boards,
- Water leakages through cracks,
- Water leakages through pipe penetration,
- Water leakages through joints,
- Corrosion of exposed drainage pipes,
- Paint peeling,
- Unevenness of tile surface
- Bad plumping

Then staff in engineering and maintenance department discussed with the medical staff the process of building rehabilitation the following results appeared:

- Repair all damaged area
- Change functions of certain sections of the floor
- Build new floor to have additional capacity of 6 operating rooms.

### 4.5.5 Corrective maintenance solution

- Removing existing paint from walls, columns and damaged ceiling areas till reaching plaster and preparing walls and ceiling for new painting see figure 4.15.

Figure 4.15 Preparing walls for maintenance

- Enlarging existing doors and windows openings
- install and test electrically operated heavy duty elevator (1600kg, 21 passenger and speed 1m/s)figure 4.16 shows the preparation for the new elevator installation

Figure 4.16 Installing new elevator

- Removing existing tiles ,skirting, cement and sand layers

- Add protection concrete around sleeves and pipes of electrical, sanitary and mechanical pipes and windows sills, external and internal lintels, parapets, canopies
- All hardware for doors shall be Original Italian Wally type or equivalent approved type and ground Jacks for operations rooms. Doors should be fitted with handles
- Steel frames should be filled with fine aggregate mortar concrete, for fixation. Price of doors should include fixing two (Norista) kick plates and door stoppers
- Supply and install solid internal wooden double swing
- The door is priming and painting with Anti-Bacteria Painting type
- The steel works including painting with priming and two layers of oil paint,
- Repair any cracks using secaflex material.
- Must make drainge for rain water on all external sills.
- Paint bondrol primer coat and three coats poliside for the ceiling and internal walls height range (120 -220cm) for cooridoors, stairs and rooms including a pendrol layer, two layers of putty as minimum, one layer of primer undercoat and two layer of oil paint
- Install non slip porsolan floor tiles
- Change water network pipes with new pipes in the ceiling figure 4.17 shows the changed pipes.

Figure 4.17 Changing water networks

- lay antibacterial PVC sheet walls 1.6 mm for the rooms of operations
- lay antistatic PVC roll tiles 2mm for the rooms of operations
- Anti-humidity and Anti-bacteria false ceiling (magnesium oxide sllicate) 60x60cm for the rooms of operation and recovery
- Copper pipe for medical gases pipes, figure 4.18 the pipes shall be cleaned, flushed and two ends capped including the risers and risers' duct covering with all connection and fittings.

Figure 4.18 Medical gazes installation in ceilings

### 4.5.6 Concluding remarks

Maintenance of important department as obstetric is considered big step forward refining health services. The most common building defects results from insufficient water and sewage network and the high occupancy of the building. After the building is maintained many advantages have resulted: provide healthier place for patients, change many rooms functions for better use and increasing of the capacity of building to receive more patients. Corrective maintenance in obstetric hospital in Shifa complex was outsourced funding with local experience supervision from ministry of health . Mainly the project is implemented depending on the available outsourced fund not on scheduled maintenance program.

## 4.6 Case study No. 2: Naser hospital building corrective maintenance for columns in second floor

### 4.6.1 Case background

Nasser hospital is a general hospital is typically the major health care facility in its region, with large numbers of beds for intensive care and long-term care; and specialized facilities for surgery, childbirth, laboratories, and so forth. Naser Hospital in Gaza strip is considered the second biggest medical institution in the Palestinian Ministry of Health located in Khanyounes city that considers secondary health care delivery system. The construction work of Naser Medical Complex began at the year 1958 under the Egyptian Administration on Khanyounis city on area around 5,000m.sq. The service started on 1960 limited with 120 Inpatient beds, on 1994 became 240 beds with increase of staff members. By the end of 2011 the hospital has 17 different medical wards, two main medical building "Naser and Al Tahreer buildings", 322 hospital beds (MOH reports, 2011).

#### 4.6.1.1 Project Description

- Project Name: Maintenance of Naser hospital building
- Location: Khanyonis city
- Project Value: USD $ 100,000
- Owner: MOH
- Donor: Islamic Relief
- Supervision: MOH

#### 4.6.1.2 Problem Identification

Naser building age has exceeded 50 years old which result many sequences on the structural elements, lack of preventive maintenance and awareness of using building in sufficient way have been showed up in the last few years. The problem started in the erosion of the columns which firstly appeared as deep cracking in the walls near the columns as shown in figures 4.19, 4.20 which

make alerts for the maintenance and engineering staff in the hospital to make intervention.

Figure 4.19 Deep cracks in the walls

Figure.4.20 Erosion appears in the column

So there was comprehensive examination of a building at Nasser Hospital and preview existing problems in the building from the engineering and maintenance staff

They found that:

- The building age was the first reason
- Bad cleaning habits from the cleaners employees
- Leakage from water lines

So the engineering and maintenance recommended the following

1. Stop the current reparations of the building immediately and wait until diagnose the problem.
2. Check all the columns in the second floor by manual examination and laboratory testing by a Schmidt Hummer.
3. Based on the results of the examination process are classified into two categories:
    a) Remove the columns affected significantly and replace it with a new section.
    b) For the least harmful columns jacketing of the column from all sides of a thickness not less than 15 cm with the addition of new reinforcing steel and bracelets and cleaning of the existing rust.

Note: there is necessary need to strengthen the roof during the treatment process in both the above two cases.

4. Examine all the causes of moisture in the building, sewer lines and water lines as well as tile in the bathrooms.
5. Examine all the reservoirs (columns, roof, and insulation work).
6. Addressing periodic and continuous maintenance for any appearing moisture and cracks in other parts of the building.

### 4.6.2 Corrective maintenance solution

The repairing and maintenance started at the beginning of the year in February 2012 and it was outsource funded from the Islamic relief and the total budget was100,000 $ for all columns maintenance work in the second floor .

Number of total columns in the floor was 150 column 20 columns was completely removed then new columns inserted and isolation and Jacketing was made for the rest.

The procedure for the maintenance was as follow:

- Columns replacement:

  Figure 4.21 illustrate on real how the preoaring for the column replacement

Figure 4.21 Preparing for jacketing

a) completely remove the affected columns “concrete and reinforcement” remove the walls which lie behind the formwork and casting process
b) Make a hole in the ceiling using the compressor to avoid major problems in the ceiling, taking into account the conservation of the roof reinforcement and to cast from this hole.
c) Reinforcement socialization in the lower ceiling by 12 steel bar Ø14mm ,100 cm length in the section according to the shape and distribution of reinforcing steel in the section (A-A) figure 4.22 to return the column in its previous case

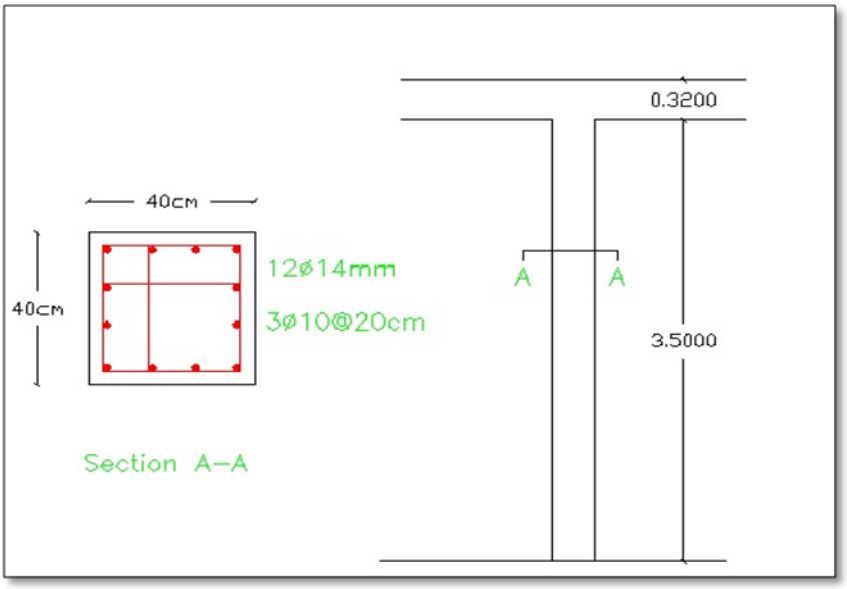



Figure 4.22 Old column cross section

d) taking into account the use of special materials to prevent the reinforcement from separation from the existing ceiling

Nasser hospital used Sikadur-31 CF normal which is a solvent free and structural two part adhesive and repair mortar, based on a combination of epoxy resins and special fillers designed for use on dry and concrete surfaces.

e) Place bracelets 10Ø every 15 cm along the column
f) Develop rebar 12Ø14 described by section (A-A).
g) Re-install isolation panels that have been removed
h) Casting tassels of reinforced concrete around the new columns
i) Re-tiling of the floors (broken marble, ceramics) according to the existing with all the necessary installation.
j) Bleaching the interior and exterior faces of the columns with paint interior and exterior sides as the existing.

### 4.6.1 Columns jacketing and osolation:

Remove walls and parts of concrete and concrete cover to get to the existing steel bars from all side of the column.

1. Remove the mangled steel completely from the column with a good cleaning of rust, and use special materials painting to stop the rust.

2. Steel socialization in longitudinal way will be 8 Ø10 mm, 20 cm length, in the section every 30 cm along the column.
3. Steel socialization for the lower ceiling 12 Ø14 mm, 100 cm length in the section according to the shape and distribution of reinforcing steel in the section (B-B) see figure 4.25.
4. Special material must be used to receive the new casted concrete with the old concrete like Sikadur-32 which is high performance bonding agent used to bond fresh cementations concrete or mortar and materials to prevent reinforcement from separation from the existing ceiling.
5. The process of casting of columns which carries the drop beams will be from the column side.
6. Plastocrete is liquid water proofer for use in all types of mortar and concrete to reduce permeability and absorption, will be added for the new casted concrete to avoid shrinkage.
7. Decorative work of a particular (crown column), which bearing the hidden beams follow the same steps in the way the cast of new columns in the previous item.
8. Complete the decor in columns (Crown) supply with gypsum plate with thickness of 2 cm as shown in figure 4.23.

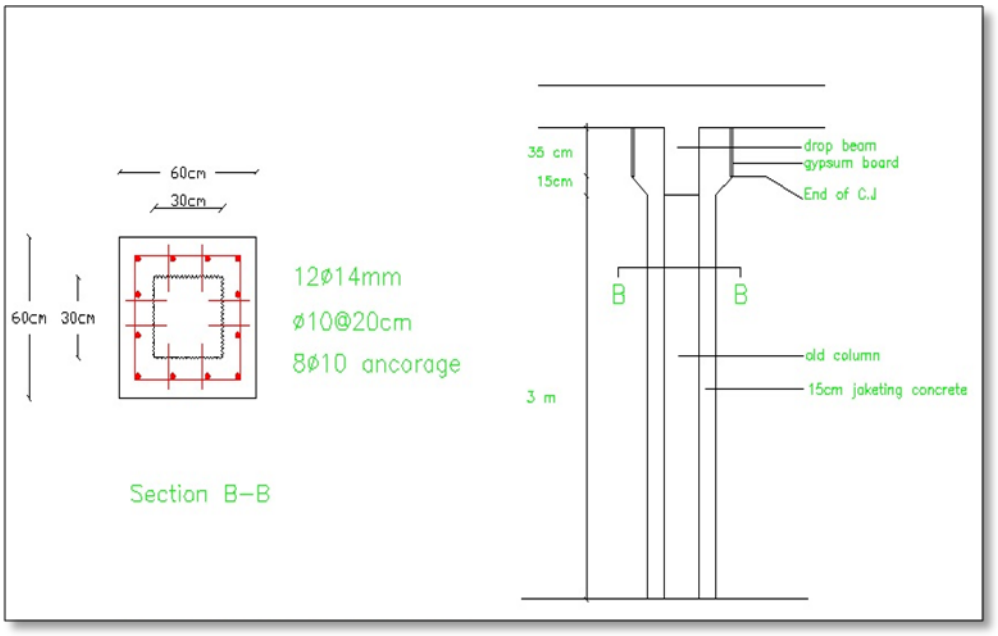



Figure 4.23 Column jacketing

9. Re-tiling of the floors (broken marble, ceramics) according to the existing with all the necessary installation.
10. Bleaching the interior and exterior of the column crown and paint interior and exterior sides as the existing.

### 4.6.2 Concluding remarks

Health building facilities are vital asset in the Palestinians people`s life any failure will be affect negatively on their life. This case study illustrated how the facility age, un controlled cleaning procedure and lack of periodic maintenance for the water and sewage system produced big problem in an important structural element.

Engineers have make their investigation and approved that there are two solution for the most harmful columns they must be removed and reconstructed and the less harm will be treated, isolated and make the jacketing system. This project was out source funded from the Islamic Relief with a budget of 100,000 $. This solution will survive for almost 10 years for maximum expectations.

# Chapter 5

# Proposed framework for application of key performance indicators in hospital building maintenance in the Gaza strip

## 5.1 Introduction

The challenge of designing the ideal frame work to drive maintenance activities has become a fundamental question to reach the effectiveness and efficiency of maintenance management and to fulfill enterprise objectives (Ma´rquez et al, 2009). This chapter will develop a framework which is suitable for Gaza strip hospital building maintenance departments to be included in the daily activities routine, which its role to arrange and develop the maintenance process through implementation of KPIs and make it more effective and applicable, making in consideration the factors that may impede the process. These KPI will Entrenches the idiom of facility management FM through execution of developed measurements and indicators which is convenient for hospital buildings. This frame work will determine the prerequisites and the current situation of available resources and potential for applying the KPIs then demonstrates the stages. It may be considered as a tool to organize and control the work done on building`s maintenance.

## 5.2 Application of KPIs

Using the appropriate equations to apply the KPIs and evaluating the results through the allowable values that approved by the maintenance management then setting new vision for the next year for maintenance plan to re arrange the current situation. Figure 5.1 shows the suitable frame work for the next stages.

## 5.3 Frame work components

### 5.3.1 Analyze the current situation

The current situation means all maintenance related internal and external matters. Internal matters include strengths and weaknesses in terms of performance and its trends, current practices, available technologies relation with other functions, and strategies and maintenance policies and practices. Classify the all the systems existed in the buildings e.g. how many systems? Are there internal self independent or transporting maintenance jobs to other parties?

Determine all the human resources existed and their skills, investigations on all stores content what available and what is not of( spare parts, building materials and needed materials for special installations) and determine the existing funds how many outsourced will be and the internal sourcing fund and its availability dates at least for the internal sourcing “from ministry of finance”.

### 5.3.2 Prerequisites stage

This stage considered as road mapping stage because it identifies the features and the component of the hospital facility, which is a missed documentation in MOH the following are the steps which the researcher recommends to be done by the maintenance departments:

1. Detailed field Survey for each building in the hospital
2. Determine the existing component of the building and their classifications
3. Prepare updated as built drawing for each component in the building \
4. Prepare check list for inspection of building component table 5.1 presents a proposed check list it can be changed upon the classification in step 2.

   This check list was done with the experienced engineers in the maintenance and engineering directorate in MoH.

Table 5.1 Proposed checklists for maintenance department inspection

| # | System | component | Time of inspection per Unit of time | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Year | 6 months | 3months | Monthly | Weekly | Daily |
| 1 | Concrete structure | Ceilings | * | | | | | |
| | | Columns | * | | | | | |
| | | Interior walls | | * | | | | |
| | | Exterior walls | | * | | | | |
| | | Shear wall if existed | | * | | | | |
| 2 | Interior finishing | Plaster | | * | | | | |
| | | Painting | | | * | | | |
| | | Floor | | * | | | | |
| | | Ceramic | | * | | | | |
| | | Windows | | * | | | | |
| | | Doors | | | * | | | |

Table 5.1Proposed checklists for maintenance department inspection (continued)

| # | System | component | Time of inspection per Unit of time | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | More 1 year | Year | 6 months | 4months | Monthly | Weekly | Daily |
| | | False ceiling according to its type: | | | | | | | |
| | | Steel | | * | | | | | |
| | | Anti Bacterial | | | * | | | | |
| | | Armstrong | | * | | | | | |
| | | Plaster and wires | * | | | | | | |
| | | Brick | | * | | | | | |
| | | Antistatic PVC floors in operation rooms | | | | * | | | |
| 4 | Water Network | Tanks | | | * | | | | |
| | | Pumps | | | * | | | | |
| | | Pipes | | | * | | | | |
| | | Fittings | | | | * | | | |
| | | Cold and hot water network | | | *(hot network) | * | | | |
| | | End accessories in operation room, WC and kitchens | | | | | * | | |
| 5 | Sewage Networks | Accessories in WC | | | | | | * | |
| | | Pipes | | | | * | | | |
| | | Pumps | | | * | | | | |
| | | Manholes | * | | | | | | |
| | | Medical waste disposal | | | | | | * | * |
| | | Drainage | | | | | * | | |
| 6 | Furniture | Beds | | * | | | | | |
| | | cupboard | | | | * | | | |
| | | chair | | | * | | | | |
| | | trolly | | * | | | | | |
| | | Move shelves | | | * | | | | |
| | | curtains | | | | * | | | |

Table 5.1Proposed checklists for maintenance department inspection (continued)

| # | System | component | Time of inspection per Unit of time | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Year | 6 months | 3months | Monthly | Weekly | Daily |
| 7 | Medical gazes | Outlets | | | | | * | |
| | | Pipes | | | | * | | |
| | | Generator Station | | | | | * | |
| 8 | Electricity | Lightning | | | | | | * |
| | | Electrical plugs | | | | | * | |
| | | Electric boards | | | * | | | |
| | | Pipes and ducts | | | * | | | |
| | Electricity | Switching equipment | | * | | | | |
| | | Conductors and cables | | * | | | | |
| | | Grounding protection | | * | | | | |
| | | Electric accessories | | | | * | | |
| 9 | Elevators | | | | | * | | |
| 10 | Air conditioning | Air conditioning | | | | | * | |
| | | Especially in operating room | | | | | | * |
| 11 | Safety Equipments | Fire extinguishing | | | | | * | |
| | | Alarm systems | | | | * | | |
| 12 | Special installations | Ventilators | | | | | * | |
| | | Vacuum | | | | | * | |

5. Human resources evaluation and allocation according to their skills and experience and try to fill the gaps.
6. Records data on failures .

7. Schedule of done activities and the received requests

### 5.3.3 Implementation stage

From the previous stages the below information must be answered correctly

1. Age of buildings, floor area and number of beds and their categories
2. The performance score of each components included in the buildings
3. Designed life cycle for building
4. Designed life cycle for each component in the building
5. Number of replacements during design life cycle for each component in the building
6. Replacement cost for each component of systems in building ($US per sq-m)
7. Annual maintenance cost for each component of systems in building ($US per sq-m).and total annual maintenance expenditure ($US per sq-m)
8. Reinstatement value for each component of systems in building ($US per sq-m)
9. Urgent repair and general repair requests numbers.

## 5.4 Success factor for KPIs implementation in the frame work

Preventive maintenance PM application can be considered as success factor which can be used as an indicator of the building performance. PM consists of the systematic inspection, detection, correction, and prevention of incipient failures, before they become actual or major failures Figure 5.2 represents a flow chart for how to began with PM .There is a need to use highly qualified personnel with continuous training in hospital maintenance. The maintenance strategy should be in line not only with the hospital strategy but also with the points of view of multiple departments.

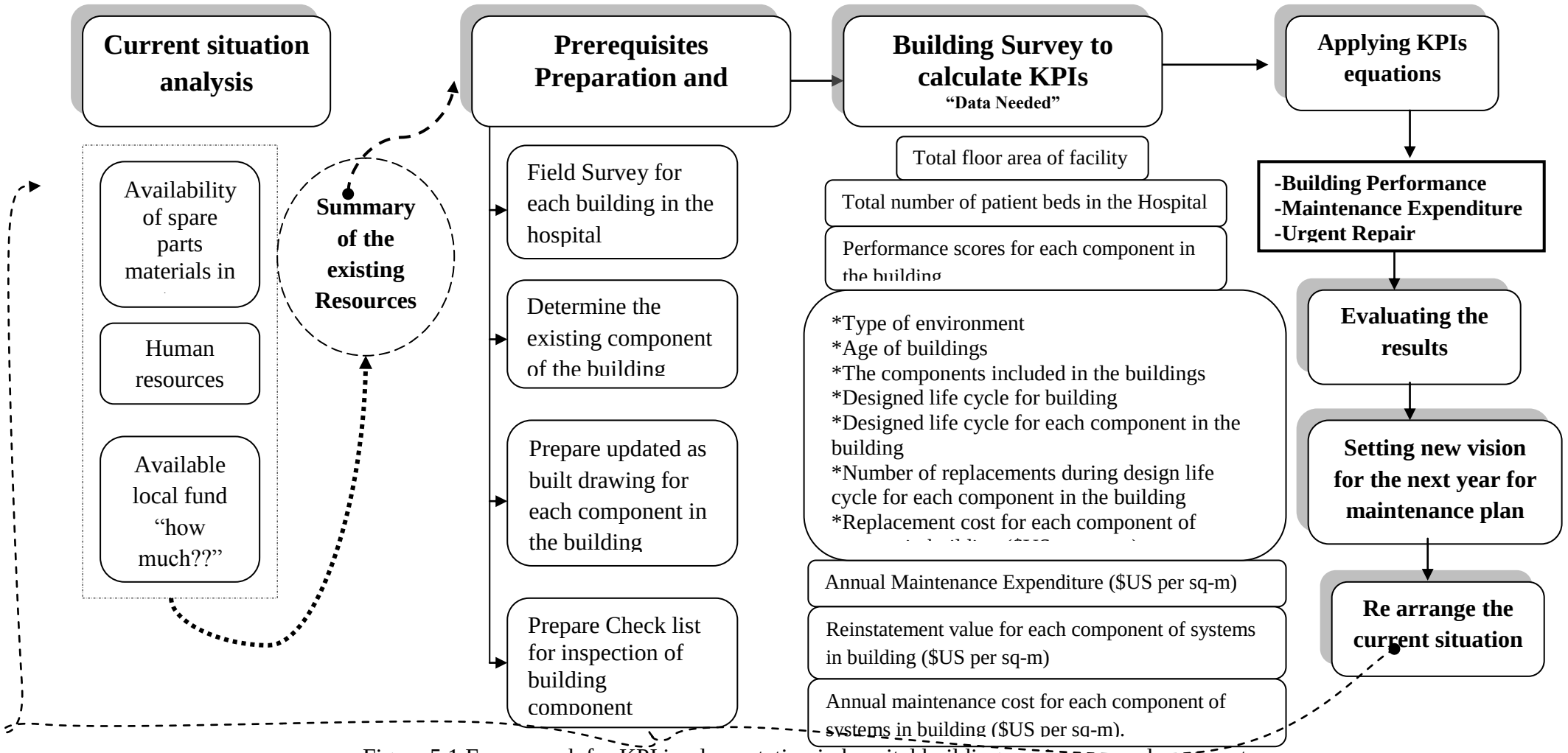



Figure 5.1 Frame work for KPI implementation in hospital buildings maintenance department

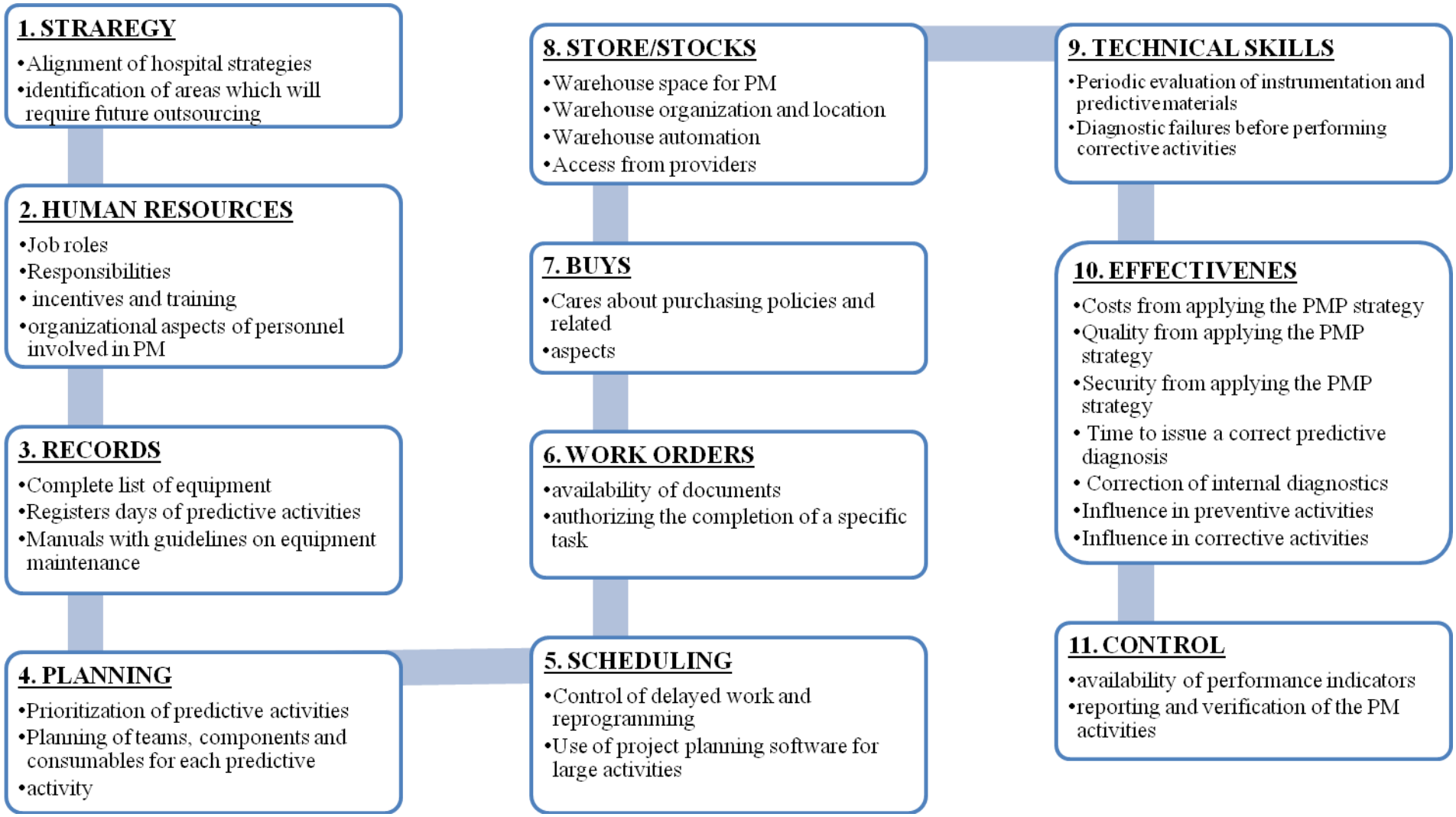


Figure5.2 Preventive maintenance requirement flow chart

# Chapter 6

# Conclusion and recommendation

## 6.1 Introduction

This study started at the middle of 2012, the main aim of this research was to study the maintenance performance indicators in order to control the operation of hospital building maintenance in Gaza strip. This chapter includes the conclusion, and applicable recommendations to improve maintenance performance in the Gaza Strip hospitals. This research had four main objectives, which were achieved through the data collection using survey techniques and the detail analysis of the survey results. The first objective was to assess the operational conditions and activities carried out by the maintenance departments of public hospital buildings in Gaza strip. The second objective was to determine factors affecting maintenance management of public hospital buildings. The third objective which is considered as the heart of the research, it was to measure the key performance indicators for maintenance in governmental hospitals, and the last one to specify the minimum requirements for the management of maintenance.

## 6.2 Conclusions

Based on the results analysis obtained from this research, the following conclusions of the research are extracted. A descriptive research was conducted to describe and evaluate the performance of the maintenance departments and the hospitals buildings in the Gaza Strip hospitals. Main factors were defined which affect the maintenance management and applying main four key performance indicators selected to be suitable for the Gaza Strip governmental hospitals.

**Objectives one: the most important results was the maintenance department performance dimensions**

- **Responsiveness and timeliness**

  The maintenance departments took few hours to respond to maintenance requests, which represents a good coordination of receiving the requests from the hospitals other departments.

- **Delivering characteristics**

  The building conditions in the hospital have improved from year to year from maintenance, and the final situation of the maintained building is getting better

There some problems for the hospital users to identify the right item to be maintained, there is difference from the actual damage to maintain and the requested maintenance.

- **Case studies**

. Corrective maintenance in obstetric hospital in Shifa complex was outsourced funding with local experience supervision from MoH. Mainly the project is implemented depending on the available outsourced fund not on scheduled maintenance program.

This case study in Nasser hospital illustrated how the facility age, uncontrolled cleaning procedure and lack of periodic maintenance for the water and sewage system produced big problem in an important structural element.

In conclusion the corrective maintenance is the main type of the maintenance projects in MoH hospitals buildings.

## Objective two: the most factors affecting maintenance management of public hospital buildings

**The conclusion from the main problems for building maintenance management was focused on the following:**

- There is no enough staff
- Not adequate fund
- poor contractors performance

**While the main sources of maintenance complains**

- Cleaning attitudes
- Plumping, water supply and waste disposal network problems
- Electrical renewing problems
- Building design inefficiencies

  It is one of the most drawbacks to the traditional way of designing and developing new buildings which does not incorporate early input from the maintenance department.
- Too many calls for service

**A ranking was done to determine the priorities of the** major cause of non maintenance of public building which was as following arranged from the highest priority:

1. Lack of maintenance culture
2. Inadequate funds
3. Blockade on Gaza Strip and restriction on the movement of goods
4. Poor work done on building
5. Bureaucratic reporting process
6. Pressure on facility/building due to number of occupants
7. Non response to maintenance request

**The maintenance staff skills also affect the maintenance management behavior and skills:**

- Experience in the maintenance gathered by collecting historical data for the identification of maintenance trends.
- Low motivation affect the work negatively by making the staff working as a machine no bouns for good work, however the punishment is applicable.
- The main causes of law motivation are poor pay, lack of opportunities for training/development and unhealthy working condition.
- No existence of planed schedule which contain a checklist makes the work out of order.
- The training for the staff and users makes the maintenance management easier.

## Objective three: to measure the key performance indicators

The following steps were done:

- Identifying all the KPIs and their calculations
- Choosing the suitable KPIs for hospital building maintenance in the Gaza Strip, four KPIs were chosen BPI, AME, MEI and URI.

  The building performance indicator (BPI) monitored the performance of various building systems. The maintenance efficiency indicator (MEI) evaluated the efficiency of resource utilization. This indicator takes four factors into consideration, namely the performance of the building, the level of annual

maintenance expenditure and the age of the building and its occupancy level. Applying the indicators and explain the results.

- The BPI was for total average performance 76.18 for the 13 hospitals which is marginal status.
- Annual maintenance expenditure, the maintenance for health facilities expenditure in Gaza Strip is lags far behind.

  The hospitals with average of $13.8 per sq m, which is under the standard level of expenditure; this is due the limited sources of hospital funding and the poor financial statement for the MOH.
- In average the maintenance expendture indicator (MEI) for Gaza hospitals was 0.3 which indicated low budgetary investment.
- Urgent repair index (URI) percents considered in the average percents. This means the engineering staff are moderately engaged in urgent repairs.

**Objective four: to specify the minimum requirements for the management of maintenance**

Preventive maintenance application considered as success factor which can be used as an indicator of the building performance maintenance and its phases:

- Analyze the current situation
- Prerequisites stage
  1. Detailed field Survey for each building in the hospital
  2. Determine the existing component of the building and their classifications
  3. Prepare updated as built drawing for each component in the building
  4. Prepare Check list for inspection of building component
  5. Gather all the needed data and the missing values
- Implementation.

## 6.3 Recommendations:

The following recommendations are the most important ones that can be derived from this research. The recommendations arranged according to the objectives:

***Recommendation for objective one***: Assess the operational conditions carried out by the maintenance departments of public hospital buildings in Gaza strip.

- Changing the work style ( rearrange the human resources, set new standards to receive the maintenance requests)
- Outline comprehensive standard training schedule for the maintenance team, medical staff, administrative staff and the management to be aware of the facility management principles.
- Prepare time scheduled plan to make a data collection survey for all the assets of the hospitals and their extensions, and convert it to maps with a full database.
- Give more priority for the financial department by allocating an accountant in each center to calculate and classify all the financial items.

***Recommendation for objective two:*** Determine factors affecting maintenance management of public hospital buildings.

- Develop a team vision for hospital maintenance department.
- Define the current human resources and coping with lack of the staff by determining the detailed responsibilities for each employee in the maintenance and engineering general directorate in MOH.
- Estimating an average or the minimum financial budget which can be available from the financial unit and design the maintenance plan.
- Changes the work culture towards a culture of maintenance requires a full commitment from all parties.

***Recommendation for objective three:*** Measure the key performance indicators.

- Start to implement preventive maintenance even if on small scale.
- Make certified periodic maintenance checklists which able to be updated.
- Develop and implement adequate KPIs for the maintenance department

***Recommendation for objective four***: Specify the minimum requirements for the management of maintenance

- Set a detailed survey for buildings.
- Setting the priorities and what the stores needs of raw materials and spare parts.
- Evolving high level of management of the importance of starting of defining the priorities.
- Classify all the types of maintenance done or its just fixing what is damaged.
- Start a preventive maintenance which will be the lead in getting better building conditions.
- Evolve the medical staff with the plans done and the trainings.

## References


Adenuga, A., Odusami, T. and Faremi, O. (2007) Assessment of factors affecting maintenance management of public hospital buildings in Lagos state Nigeria, *The construction and building research conference of the Royal Institution of Chartered Surveyors*, Available from: http://www.rics.org/site/download_feed.aspx?fileID=3339...PDFSimilar[ Accessed on 3/2/2012].

Adenuga, O. (2010) Labour composition for maintenance works in public hospital built environment in south west, Nigeria, *Journal of Building Performance*, Vol. 1, No.1, pp.83-97.

Afolarin, A. (2012) Maintenance managements practices in public hospital built environment Nigeria case study, *Journal of Sustainable Development in Africa*, Vol. 14, No.1, pp.185-201.

Ahmed, M. and Dhafr, N. (2002) Establishing and improving manufacturing performance measures, *Robotics and Computer Integrated Manufacturing*, Vol.18, pp. 167-171.

Ahzahar, N., Karim, N., Hassan, S. and Eman, J. (2011) A study of contribution factors to building failures and defects in construction industry, Procedia Engineering, Vol. 20, pp. 249 – 255.

Al Bashir, A., Al Rawashdeh, M., Al Hadithi, R., Al Ghandoor, A. and Barghash, M. (2012) Building medical devices maintenance system through quality function deployment, *Jordan Journal of Mechanical and Industrial Engineering*, Vol.6, No.1, pp.25-36.

Al Zubaidi, H. (1997), Assessing the demand for building maintenance in a major hospital complex, *Property Management*, Vol.15, No. 3, pp. 173–183.

Alexander, K. (2011), Building control and performance: as if people and the planet matter, *Procedia Engineering*, Vol. 20, pp. 1-11.

Ali, M. and Mohamad, W. (2009) Audit assessment of the facilities maintenance management in a public hospital in Malaysia, *Journal of Facilities Management*, Vol. 7, No.2 , pp. 142 – 158.

Al-Khatam, J. (2003) Buildings maintenance cost, Dhahran, Saudi Arabia, Unpublished (MSc) thesis, King Fahd University of Pertoleum & Minerals.

ALwaer, H. and Croome, D. (2010) Key performance indicators (KPIs) and priority setting in using the multi-attribute approach for assessing

sustainable intelligent buildings, *Building and Environment*, Vol. 45, pp. 799–807.

Balaras, C., Dascalaki, E. and Gaglia , A. (2006) HVAC and indoor thermal conditions in hospital operating rooms, *Energy and Buildings*, Vol.39, PP.454–470.

Bank, M. and Kelsey, C. (1995) Radiation information for hospital personnel, Published for the American Association of Physicists in Medicine, Available from: **http://www.aapm.org/pubs/reports/rpt_53.pdf** [Accessed on 1/8/2012].

Bin Hashem, A., (2006) Maintenance management and services case study Perkeso building`s in Penisular of Malaysia, Unpublished MSc. thesis, University Technology of Malaysia.

Cardoen, B., Demeulemeester, E. and Beliën, J. (2010) Operating room planning and scheduling: a literature review, *European Journal of Operational Research*, Vol. 201, pp.921–932.

Chanter, B. and Swallow, P. (2006) Building maintenance management, Blackwell Publishing Ltd., UK.

Ching , H., Shen-Wen, C., Chien-Hung, L., Po-Ta, H., Yi-Ting, S. and Huei-Ru, S. (2011) A Study for the evacuation of hospital on fire during construction, *Procedia Engineering*,Vol.11 ,pp.139–146.

Chotipanich, S. (2004), Positioning facility management, *Facilities*, Vol. 22, No. 13, pp. 364 – 372.

Chow, T. and Yang, X. (2003) Performance of ventilation system in a nonstandard operating room, *Building and Environment*, Vol.38, pp. 1401 -1411.

Cobbinah, P. (2010) Maintenance of buildings of public institutions in Ghana case study of selected institutions in the Ahanti region of Ghana, Unpublished (MSc) thesis, Kwame Nkrumah University of Science and Technology, Kumasi, Available from: http://dspace.knust.edu.gh:8080/jspui/bitstream/123456789/190/1/Prince%20Jude%20Cobbinah%20Thesis.pdf [Accessed on 1/8/2012].

Cooper, J. and Jones, K. (2008) Sustainable social housing maintenance, University of Greenwich, Available from: http://www.serg.soton.ac.uk/idcop/outcomes/IDCOP%20WP%202.1%20Questionnaire-Analysis.pdf [Accessed on 1/9/2012].

Cruz, A. and Rincon, A. (2012) Medical device maintenance outsourcing: have operation management research and management theories forgotten the medical engineering community? a mapping review, *European Journal of Operational Research*, Vol.221, pp.186-197.

Dennis, G. (2009) Assest maintenance policy, The university of Queensland, Available from: http://www.pf.uq.edu.au/pdf/MaintenancePolicy.pdf [Accessed on 10/10/2012].

Department of veterans (2008) Radiology service design guide, available from: **http://www.wbdg.org/ccb/VA/VADEGUID/radio.pdf** [Accessed on 1/8/2012].

Dhillon, B. (2002) Engineering maintenance: a modern approach, CRC Press LLC, United States of America, available from: http://site.iugaza.edu.ps/sabdelall/files/2010/02/Engineering_Maintenance_a_modern_approach.pdf [Accessed on 15/7/2012].

Morris, E. (2004) Sampling from small populations, Available from**http://uregina.ca/~morrisev/Sociology/Sampling%20from%20small%20populations.htm**[Accessed on 11 /1/2013].

Fellows, R. and Liu, A. (2008) Research methods for construction, Blackwell Publishing Ltd, UK.

Fixit Institute, (2010) Understanding common building defects, *Solutions and maintenance management Rebuild*, Vol.2, No.4, pp.5-12.

Garip, E. (2011) Environmental cues that affect knowing: a case study in a public hospital building, *Procedia Social and Behavioral Sciences*, Vol. 30, pp. 1770 – 1776.

Giff, G. and Crompvoets, J. (2008) Performance indicators: a tool to support spatial data infrastructure assessment, *Computers Environment and Urban Systems*, Vol.32, pp. 365-376.

Highley, D. (2009) Medical gases: their storage and delivery, *Anesthesia and Intensive care Medicine*, Vol.10 No.11, pp. 523-527.

Horner, R., El-Haram, M. and Munns, A. (1997) Building maintenance strategy: a new management approach, *Journal of Quality in Maintenance Engineering*, Vol. 3 No. 4, pp. 273-280.

Ikhwan, M. and Burney, F. (1999) Maintenance in hospitals of Saudi Arabia, Industrial Engineering Department, Faculty of Engineering, King Abdulaziz University, Jeddah, Saudi Arabia, *Engineering Science*, Vol. 11, No. 2, pp. 61-68.

Jardali, F., Saleh, S., Ataya, N. and Jamal, D. (2011) Design, implementation and scaling up of the balanced scorecard for hospitals in Lebanon: policy coherence and application lessons for low and middle income countries, *Health Policy* ,Vol.103, pp.305– 314.

Kagioglou, M., Cooper, R. and Aouad, G. (2001) Performance management in construction: a conceptual framework, Research Institute for Design and Manufacture, University of Salford, Centenary Building.

Kennett, M. (2006) Hospital design considerations, Fema, Available from **http://www.fema.gov/library/file?type...file**... [Accessed on 20/5/2012].

Key performance indicators, (2012) Wikipedia, Available from: **http://en.wikipedia.org/wiki/Key_performance_indicators** [Accessed on 8/11/2012].

Kincaid, D. (1994) Integrated facility management, *Facilities*, Vol. 12, No.8, pp. 20-23.

Kothari, C. (2004) Research Methodology: methods and techniques, New Age International Ltd.

Kutucuoglu, K., Hamali, J., Irani, Z. and Sharp, J. (2001) A framework for managing maintenance using performance measurement systems, *International Journal of Operations and Production Management*, Vol. 21, No.1, pp. 173 – 195.

Lam, E., Chan, A. and Chan, D. (2010) Qualitative survey on managing building maintenance projects, *World Academy of Science Engineering and Technology*, Vol.65, pp.232-236.

Lam, k. (2008) Design for maintenance from the viewpoint of sustainable hospital buildings, Available from: **http://mail.airah.org.au/downloads/2007-12-02.pdf** [Accessed on 14/2/2012].

Lavy, S. (2006) Integrated facility management and its implementation to hospitals in Israel, Haifa Israel, Unpublished PhD thesis, Technion Occupied Palestinian Territories (Israel)Institute of Technology.

Lavy, S. and Shohet, I. (2004) Integrated maintenance management of hospital buildings: a case study, *Construction Management and Economics*, Vol.22, pp. 25–34.

Lavy, S. and Shohet, I. (2010) Performance based facility management: an integrated approach, *International Journal of Facility Management*, Vol.1, No.1, pp.1-14.

Lind, H. and Muyingo, H. (2012) Building maintenance strategies: planning under uncertainty, *Property Management*, Vol. 30 No. 1, pp. 14-28.

Lourenco, P., Luso, E. and Almeida, M. (2006) Defects and moisture problems in buildings from historical city centers a case study in Portugal, *Building and Environment*, Vol. 41, pp.223–234.

McClay, G. (2009) Hospital maintenance mechanic, Available from: **http://www.co.monterey.ca.us/personnel/documents/specifications/72C19.pdf** [Accessed on 1/11/2012]

Ministry of Health, PHIC, Health Status in Palestine 2011, May 2012, Ministry of Health –Palestine -Ramallah.

Ministry of Health-Gaza strip (2010) Hospital annual report 2010, Palestinain Health Information Center (PHIC), Ministry of Health -Palestine- Gaza strip .

Ministry of Health-Gaza strip (2011) Hospital annual report 2011, Palestinain Health Information Center (PHIC), Ministry of Health -Palestine- Gaza strip .

MoyJr, F. (1995) Facility wellness health facilities management, *Facilities*, Vol. 13, No. 9, pp.45 – 48.

Murad, A. (2010) Evaluation of medical equipment management in governmental health facilities in Gaza Governorates, Gaza strip-Palestine, Unpublished MSc thesis, Al Quds University.

Mutia, D., Kihiu, J. and Maranga, S. (2012) Maintenance management of medical equipment in hospitals, *Industrial Engineering Letters*, Vol. 2. No. 3, pp. 9-20.

Nik-Mat, N., Kamaruzzaman, S. and Pitt, M. (2011) Assessing the maintenance aspect of facilities management through a performance measurement system a Malaysian case study, *Procedia Engineering*, Vol.20, pp.329 – 338.

Nudurupati, S., Arshad, T. and Turner, T. (2007) Performance measurement in the construction industry: an action case investigating manufacturing methodologies, *Computers in Industry*, Vol. 58, pp. 667–676.

OLA. (2000) A best practice preview preventive maintenance for local government buildings, 6th Report of Office of the Legislative Auditor, St. Paul, Minnesota, U.S.A.

Olajide,F. and Afolarin, A. (2012) Evaluation of maintenance management practice in banking industry in Lagise state Nigeria, *International Journal*

*of Sustainable Construction Engineering and Technology*, Vol.3,No. 1, pp.45-53.

Palestinian Central Bureau of Statistics, 15 January, 2012, < http://www.pcbs.gov.ps/>.

Parida, A. and Kumar, U. (2006) Maintenance performance measurement (MPM) issues and challenges, *Journal of Quality in Maintenance Engineering*, Vol. 12, No. 3 pp. 239 – 251.

Popova, V. and Sharpanskykh, A. (2010) Modeling organizational performance indicators, *Information Systems*, Vol. 35, pp. 505-527.

Queensland Department of Public Works (2011), Maintenance management framework Policy for the maintenance of Queensland Government buildings, Available from: **http://www.works.qld.gov.au/downloads/bpu/mmf_policy.pdf** [Accessed on 15/3/2012].

Reymondon, F., Pelletc, B. and Marcon, E. (2008) Optimization of hospital sterilization costs proposing new grouping choices of medical devices into packages, *Production Economics*, Vol.112, pp. 326–335.

Shah Ali, A., Kamaruzzaman, S., Sulaiman, R. and Peng, Y. (2010) Factors affecting housing maintenance cost in Malaysia, *Journal of Facilities Management*, Vol. 8 No. 4, pp. 285 – 298.

Shohet, I. (2003) Key performance indicators for maintenance of health care facilities, Facilities, Vol.21, No.1/2, pp. 5-12.

Silva, J. and Falorca, J. (2009) A model plan for buildings maintenance with application in the performance analysis of a composite facade cover, *Construction and Building Materials*, Vol.23 , pp.3248–3257.

Silva, N., Dulaimi, M., Ling, F., and Ofori, G. (2004) Improving the maintainability of buildings in Singapore, *Building and Environment*, Vol.39, pp. 1243 – 1251.

Takim, R. and Akintoye, A. (2002) Performance indicators for successful construction project performance, In: Greenwood, D (Ed.), 18th Annual ARCOM Conference, *Association of Researchers in Construction Management*, Vol. 2, pp.545-55.

Takim, R., Akintoye, A. and Kelly, J. (2003) Performance measurement systems in construction, 19th Annual ARCOM Conference, *Association of Researchers in Construction Management*, Vol. 1, pp.423-432.

Tavakoli, H., Karami, M., Rezai, J., Esfandiari, K. and Khashayar, P. (2007) When renewing medical equipment is necessary: a case report, *International Journal of Health Care Quality Assurance*, Vol. 20, No. 7, pp. 616-619.

The World Bank (2008) West Bank and Gaza health policy report performing prudently under pressure health financing reform and the rationalization of public sector health expenditures,(D, Gressani ), The world bank, Human Development Sector, Middle East and North Africa Region

Toor, S. and Ogunlana, S. (2010) Beyond the 'iron triangle': stakeholder perception of key performance indicators (KPIs) for large-scale public sector development projects, *International Journal of Project Management*, Vol.28, pp. 228–236.

Tsang, A. (1998) A strategic approach to managing maintenance performance, Journal of Quality in Maintenance Engineering, Vol. 4, No.2, pp. 87 – 94

Veerabadran, S. and Parkinson, I. (2010) Cleaning disinfection and sterilization of equipment, *Anaesthesia and intensive care medicine*, Vol.11, pp.451-454.

Weber, A. and Thomas, R. (2005) Key performance indicators measuring and managing the maintenance function, Available from:http://www.plantmaintenance.com/articles/KPIs.pdf [Accessed on 5/2/2012]

World health organization, United nation development programme, and United nations educational scientific and cultural oganization and Ministry of health report (2010), Assessment of public health estate in Gaza, World health organization draft report.

Wilson, A. and Ridgway, G. (2006) Reducing hospital-acquired infection by design: the new University College London Hospital, *Journal of Hospital Infection*, Vol. 62, pp.264–269.

Yahya, M. and Ibrahim, M. (2012) Building maintenance achievement in high rise commercial building: a study in Klang valley Malaysia, *International Journal of Sustainable Development*, Vol.04, No. 6, pp.41-46.

Yam, R., Yuen, P., Yung, R. and Choy, T. (2011) Rethinking hospital general ward ventilation design using computational fluid dynamics, *Journal of Hospital Infection*, Vol. 77, pp. 31-36.

Zawawi, E. and Kamaruzzaman, S. (2009), Personnel characteristics of maintenance practice a case of high rise office Buildings in Malaysia, *Journal of Sustainable Development*, Vol. 2, No. 1, pp.111-116.

Zawawi, E., Kamaruzzaman, S., Ali, A. and Sulaiman, R. (2010) Assessment of building maintenance management in Malaysia: resolving using a solution diagram, *Journal of Retail and Leisure Property*, Vol. 9, No. 4, pp. 349–356.

Zawawi, E., Kamaruzzaman, S., Ithnin, Z. and Zulkarnain, S. (2011) A conceptual framework for describing CSF of building maintenance management, *Procedia Engineering*, Vol.20, pp.110 – 117.

# Appendix A

## Questionnaire

The Islamic University of Gaza

الجامعة الإسلامية –غزة

High Studies Deanery

عمادة الدراسات العليا

Faculty of Engineering

كلية الهندسة

Construction Management Master Program

*Questionnaire for Thesis In*

# KEY PERFORMANCE INDICATORS FOR MAINTENANCE IN HOSPITALS BUILDINGS

# IN GAZA STRIP

# مؤشرات الأداء الأساسية لصيانة مباني المستشفيات في قطاع غزة

Done By:

Farida Emad El Shorafa

Supervised by

Prof. Dr. Adnan Enshassi

Professor of construction Engineering and Management

October 2010

The Islamic University of Gaza

High Studies Deanery

Faculty of Engineering

**Questionnaire for**

# Key performance indicators in maintenance of hospital buildings in the Gaza Strip

Dear Sir,

I am a graduate student at Islamic University in Gaza. I am now preparing a master thesis in the construction management program. The title of the thesis is:

**"Key performance indicators in maintenance of hospital buildings in the Gaza Strip"**

The purpose of the study is to:

1. Assess the operational conditions carried out by the maintenance departments of public hospital buildings in Gaza strip.
2. Determine factors affecting maintenance management of public hospital buildings.
3. Measure the key performance indicators and compare the results.
4. Specify the minimum requirements for the management of maintenance.

The results of the study will be of great help to the industry and offering valuable results for all. As you are one of the large organizations working in this field in Gaza, we are kindly inviting you to participate in filling this questionnaire with the required data which is an important element in this study.

The information provided by you will be analyzed as whole, and we ensure you that this information will be held in strict confidence and used for the scientific research purpose only.

We realize that there are numerous demands on your time. However your involvement is a vital requisite for this study. We appreciate your anticipated cooperation in answering this questionnaire

Thank you for your anticipated cooperation.

Best regards.

Supervisor Prof**. Adnan Enshassi** Researcher Eng**. Farida E. El Shorafa**

## Part 1: General Information of the Selected Hospitals Buildings

1. Hospital Name:_____
2. Hospital location:_____
3. Geographical region: Coast / In-land
4. Total area in m2_____
5. Number of buildings:_____

| No. | Floor area (m2) | Year of occupancy |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |

6. Hospitals Building Age:

☐1 – 5 years ☐ 6-10years ☐ 11-15 years

☐16-20years ☐ 21-25years ☐ 26-30years ☐more than 30 years

7. Total Number of beds: _____
   a. Acute-care hospitalization: _____
   b. Day-care hospitalization:_____

8. Monthly Beds utilization rate:_____
   (equation):_____

9. What type of maintenance has been carried out in hospital building?

☐Preventive Maintenance ☐Corrective Maintenance

☐Immediate Maintenance ☐Routine Maintenance

*Corrective maintenance means to bring an item back to working when it has failed

10. Please indicate types of maintenance activities during the 2012:

……

……

……

……

……

11. Maintenance annual total budget? _____$

    a. Internal sourcing budget _____$

    b. Out sourcing Budget_____$

**Part 2 :Performance measurement dimensions:**

12. How long does it take to respond to maintenance request/needs of personnel?

☐from 1- 6 hr ☐ 1day ☐ week

☐month ☐ more than 1 month

13. Do technicians receive training to conduct the condition assessments of the buildings?

☐Yes ☐ No

14. Does the department have a written long-range plan for building maintenance and repairs that extends out a minimum of three to five years?

☐Yes ☐ No

15. Have building conditions in the hospital improved or stayed at acceptable levels from year to year?

☐Yes ☐ No

16. In general, describe the final situation of the maintained building:

☐Better ☐the same ☐worse

17. Does the maintained item related to the maintenance request

☐Yes ☐ No

**Part 3: Information of the Selected Hospitals Buildings Maintenance Department**

Department information

Total number of employees_____

No. of management personnel and their categories_____

……

……

……

No. of engineers:

____Civil engineers

____Architect engineers

____ Bio Medical engineers

____ Mechanical engineers

____ Electrical engineers

| Profession | Number of Jobs | | | |
|---|---|---|---|---|
| | Engineer | Practical Engineer | Technician | Other (specify) |
| Principal engineer and deputy manager | | | | |
| Maintenance manager | | | | |
| Electricity | | | | |
| Air-conditioning | | | | |
| Water and plumbing | | | | |
| Structure and Finishes | | | | |
| Communications | | | | |
| Medical gases | | | | |
| Metal workshop | | | | |
| Carpentry workshop | | | | |
| Secretary | | | | |
| Elevators | | | | |
| Fire protection | | | | |
| Bio Medical | | | | |
| Painters | | | | |
| Total | | | | |

## *Part 4: Maintenance Department Activities in hospitals buildings*

18. **Medical Equipments Maintenance procedure**

| **Activities** | **Yes** | **No** | **Comments** |
|---|---|---|---|
| Does the hospital have maintenance plan for equipment? | | | |
| Does the hospital have maintenance and repair manuals for hospital equipment in one location? | | | |
| Is there a master record of maintenance for each piece of equipment exists in the hospital? | | | |
| Is there an action record that details the scheduled maintenance to be performed for each piece of equipment on a regular basis or schedule? | | | |
| Are there routine inspections and replacement of defective parts for mechanical medical systems like oxygen generation equipment, ventilators, ……etc? | | | |

19. **Plumbing and Water Systems Maintenance**

| **Activities** | **Yes** | **No** | **Comment** |
|---|---|---|---|
| Are there routine inspection of plumbing and water systems occurs? | | | |
| Are there replacement of worn washers and defective plugs | | | |

20. **Please indicate the number of Civil works activities frequency**

| **Activities** | **No.** | **Period(week,month,year)** |
|---|---|---|
| Painting and washing down | | |
| Road and pathways repaired | | |
| Drainage and sewage work performed | | |
| Water networks | | |
| Roof and gutter maintenance performed | | |
| Floors finished | | |
| Electrical rewiring | | |
| Other: replacement of sinks, shelves, windows and doors | | |

21. **What do you believe are the problems that hospitals face in terms of building maintenance? *(Please tick as many as appropriate*)**

☐ Not enough staff ☐ Building design inefficiencies

☐ Too many calls for service ☐ Service administration inefficiencies

☐ Not enough money ☐ Poor construction quality

☐ Poor contractor performance ☐ Other, *please state*

22. **What are the major sources of maintenance related complaints?** ***Please tick as many as apply***

☐Cleaning ☐Indoor Air Quality ☐Plumbing

☐Choice of Materials ☐Repair/Replace ☐Heat Loss/Gain

☐Storage ☐Equipment ☐Waste Disposal

☐Fire Protection ☐Sound Penetration ☐Design

☐Water Supply ☐Telecommunications ☐Lighting

☐Other, please specify ……

23. **Number of urgent repair requests in 2012……**

24. **Number of general repair requests in 2012……**

**Major Cause of Non Maintenance of public hospital building**

25. How will you rank the following as the major cause of non maintenance of public building if it is so? Please rank from 1st to 7th, with first being the major reason and seventh being the least reason.

| **Causes of maintenance problem** | **Rank** |
|---|---|
| Blockade on Gaza Strip and restrictions on the movement of goods | |
| Lack of maintenance culture | |
| Inadequate funds | |
| Bureaucratic reporting process | |
| Pressure on facility/building due to number of occupants | |
| Poor work done on building | |
| Non response to maintenance request | |

## 4.2 Maintenance Staff skills and behavior factors

26. Do you use historical data to identify maintenance trends?

☐Yes ☐No

27. Level of Motivation of Maintenance staff by the management

☐Very low ☐ Low ☐Average ☐High ☐Very high

28. Causes of low motivation of maintenance workers

☐Lack of working tools/ equipment/materials

☐Irregular payment of salaries

☐Delayed promotion

☐Poor pay

☐Lack of opportunities for training/development

☐Job insecurity Unsafe/unhealthy working condition

29. Are there training programme for users on how to effectively manage the facilities within the hospital buildings?

☐Yes ☐No

30. Training type given by the management to the users through Maintenance Department:

☐In-Service Training ☐Training on Do-it-Yourself method

☐User's guide distributed for reading

31. Do technicians and managers receive training to conduct the condition assessments of the buildings?

☐Yes ☐No

32. Hospital buildings maintenance needs special training, what kind of training you receive in the department of maintenance.

……

……

……

…….....

33. Percentage of councils outsourcing hospital maintenance?

34. Number of maintenance projects outsourced……..

……

……

…….....

35. Number of maintenance projects internal sourced……

……

…….

36. Satisfaction levels with outsourced maintenance services

☐Poor ☐Fair ☐Good ☐Very good ☐Don`t know

## Part 5 : Key Performance indicators measurements

37. Future value annuity factor_____
38. Annual interest rate [%]_____
39. Annuity present value factor_____
40. Present value annuity factor.-_____

41. **Please Fill for each building separate sheet**
**Hospital Name : _____ Building Number:_____**

**Evaluate the performance of each component from (0 – 100) according to the performance scale in appendix A**

| | Component | Performance | Number of replacement during life cycle | Annual maintenance cost ($/m2) | Replacement cost in year 2012($/m2) | Reinstatement value ($/m2) |
|---|---|---|---|---|---|---|
| **1** | **Structure** | | | | | |
| | Columns | | | | | |
| | Beams | | | | | |
| | Ceilings | | | | | |
| **2** | **Exterior envelope** | | | | | |
| | Windows | | | | | |
| | Exterior walls | | | | | |
| | Roofing | | | | | |
| | Exterior claddings | | | | | |
| **3** | **Interior finishes** | | | | | |
| | Doors | | | | | |
| | Plaster | | | | | |
| | Paintings | | | | | |
| | Ceramic tiles | | | | | |
| | Acoustic tiles | | | | | |
| | Flooring | | | | | |
| **4** | **Electricity** | | | | | |
| | Electricity system | | | | | |
| | Electric boards | | | | | |
| | Transformers | | | | | |
| | Pipes and ducts | | | | | |
| | Switching equipment | | | | | |
| | Conductors and cables | | | | | |
| | Grounding protection | | | | | |
| | Electric accessories | | | | | |
| | Lighting accessories | | | | | |
| | Peripheral | | | | | |

| | Component | Performance | Number of replacement during life cycle | Annual maintenance cost ($/m2) | Replacement cost in year 2012($/m2) | Reinstatement value ($/m2) |
|---|---|---|---|---|---|---|
| | lighting | | | | | |
| **5** | **Sanitary systems** | | | | | |
| | Water supply system | | | | | |
| | Sanitary accessories | | | | | |
| **6** | **HVAC** | | | | | |
| | Compressor | | | | | |
| | Condensers | | | | | |
| | Fan-coil units | | | | | |
| | HVAC pipes | | | | | |
| | Pumps | | | | | |
| | Ductworks | | | | | |
| | Electric boards for HVAC system | | | | | |
| | Window units | | | | | |
| | Bellows / fans | | | | | |
| | Cooling towers | | | | | |
| **7** | **Fire Protection** | | | | | |
| | Fire detection | | | | | |
| | electric boards Manual / automatic | | | | | |
| | fire extinguishing | | | | | |
| **8** | **Elevators** | | | | | |
| | Machine room | | | | | |
| | Control panel | | | | | |
| | Elevators doors | | | | | |
| | Chambers | | | | | |

| | Component | Performance | Number of replacement during life cycle | Annual maintenance cost ($/m2) | Replacement cost in year 2012($/m2) | Reinstatement value ($/m2) |
|---|---|---|---|---|---|---|
| | Suitability to handicapped | | | | | |
| | Pneumatic delivery | | | | | |
| | system | | | | | |
| **9** | **Communications and low-voltage** | | | | | |
| | Public announcement | | | | | |
| | CCTV | | | | | |
| | Telephone system | | | | | |
| | Alarm | | | | | |
| | Patient-nurse calling system | | | | | |
| | Building control system | | | | | |
| **10** | **Medical gases** | | | | | |
| | Medical gases system | | | | | |
| | (piping, boards, accessories | | | | | |

42. Annual Maintenance Expenditure [$US per sq-m]

…….

43. Total Annual Maintenance Expenditure [$US] …….

# Appendix B

## Performance scale

**Performance scales**

STRUCTURE

Columns

| **100**<br>**VERY GOOD** | **80**<br>**GOOD** | **60**<br>**MARGINAL** | **40**<br>**RUN-DOWN** | **20**<br>**DANGEROUS** |
|---|---|---|---|---|
| No cracks and no sign of corrosion whatever. | Merely localized hair-cracks discernible here and there, but no signs of corrosion. | Existence of vertical cracks due to corrosion of reinforcement bars in isolated locations. | Existence of diagonal cracks up to 0.5mm wide crossing the section. Shedding of concrete has begun, exposing the reinforcement | Existence of diagonal cracks above 0.5mm crossing the section of the column, or fracture/buckling of concrete has already taken place. |

Beams

| **100**<br>**VERY GOOD** | **80**<br>**GOOD** | **60**<br>**MARGINAL** | **40**<br>**RUN-DOWN** | **20**<br>**DANGEROUS** |
|---|---|---|---|---|
| No cracks and no corrosion in the structural beams. | Localized randomly distributed cracks up to 0.1mm wide appear here and there. | 0.3mm wide cracks appear, especially in the central third of the span, but neither breakage nor buckling of concrete is discernible. | Cracks up to 0.5 mm wide appear close to supports, or significant cracking at the center of the span. | Diagonal cracks run close to supports, or heavy corrosion has already begun to develop, accompanied by shedding of concrete. |

Ceilings

| **100**<br>**VERY GOOD** | **80**<br>**GOOD** | **60**<br>**MARGINAL** | **40**<br>**RUN-DOWN** | **20**<br>**DANGEROUS** |
|---|---|---|---|---|
| No cracks or other visible damage to the ceilings. | Randomly distributed diagonal cracks up to 0.2mm wide next to an anticline arch or up to 0.5mm wide elsewhere, especially in a ceiling forming the bottom of a roof. | Cracks up to 0.5mm wide are randomly distributed over the building and covering not more than 5% of the ceiling. | Cracks over 0.5mm wide and over 1m long appear. Shedding of plaster and concrete, so a part of the reinforcement bars are exposed (up to 10% of the surface area of the ceiling). | Vertical cracks above 1mm wide. Shedding of plaster and concrete, so that a considerable part of the reinforcement bars are exposed (above 10% of the surface area of the ceiling). The corrosion is very highly developed. |

EXTERIOR ENVELOPE

Windows

| 100<br>VERY GOOD | 80<br>GOOD | 60<br>MARGINAL | 40<br>RUN-DOWN | 20<br>DANGEROUS |
|---|---|---|---|---|
| The frames are undamaged, almost no defects, no penetration of moisture through openings. | Beginning wear in a few casements or frames, e.g. cracked paint, broken or missing metal fittings, etc. | Beginning general wear, e.g. peeling paint, or certain instances of mechanical damage that can be repaired in the course of a general overhaul. | Considerable wear of wooden parts (cracks, rot). Moisture penetrates openings. Physical damage. Many parts have to be replaced | Most of the openings cannot be repaired. Moisture penetrates the building. Mechanical damage to frames and casements. Cracks in the contact area between frame and wall. |

Exterior walls

| 100<br>VERY GOOD | 80<br>GOOD | 60<br>MARGINAL | 40<br>RUN-DOWN | 20<br>DANGEROUS |
|---|---|---|---|---|
| There are no cracks or other visible damage to the exterior walls. | Localized randomly scattered cracks up to 0.1mm wide appear here and there. | Cracks up to 0.5mm wide are observed in few places, particularly around concrete elements joints. | Diagonal cracks up to 1.5mm run between openings, or close to columns | There are diagonal cracks of more than 1.5mm, or there are places in which the exterior wall has separated from the structural elements. |

Roofing

| 100<br>VERY GOOD | 80<br>GOOD | 60<br>MARGINAL | 40<br>RUN-DOWN | 20<br>DANGEROUS |
|---|---|---|---|---|
| There are no cracks or other visible damage to the roofing, there are no signs of leakage of water into the uppermost floor, drainage system is complete, and water from | There are no cracks to the roofing, and no signs of water on roof. The drainage system is satisfactory, but the waterproofing layer appears to be worn out. | There are cracks observed on the waterproofing layer, however, water does not leak yet into the building. The drainage system is insufficient for removing the water from the building's | Cracks are observed on the waterproofing layer, which leads to wetness on top floor ceilings. The drainage system is insufficient for removing the | There are wide cracks observed on the waterproofing, which lead to water leakage into the building. Water is not satisfactorily removed from roofing, drainage pipe is |

| | | | | |
|---|---|---|---|---|
| roofing is satisfactorily removed. | | roofing. | water from the building's roofing. | inefficient, roofing slope |

INTERIOR FINISHES
Doors

| **100 VERY GOOD** | **80 GOOD** | **60 MARGINAL** | **40 RUN-DOWN** | **20 DANGEROUS** |
|---|---|---|---|---|
| Undamaged frames, practically no defects, no penetration of moisture through the doors. | Beginning wear in a small number of openings or frames, e.g. cracked paint, broken or missing metal fittings, etc. | Beginning general wear, e.g. peeling paint or a few mechanical defects that can be repaired during general overhaul. | Considerable wear of wooden parts (cracks, rot). Moisture penetrates through the doors. There are physical defects. Many parts must be replaced. | Most of the openings cannot be repaired. Moisture penetrates into the interior of the building. Mechanical damage to frames and openings, cracks in the contact space between frame and wall. |

Plaster

| **100 VERY GOOD** | **80 GOOD** | **60 MARGINAL** | **40 RUN-DOWN** | **20 DANGEROUS** |
|---|---|---|---|---|
| The coating is perfect; there are neither cracks nor peeling. No moisture penetrates into the interior of the building. | Localized haircracks not more than 0.5mm wide discernible on the interior coating. No moisture penetrates the building. | Significant cracks (0.5mm wide) cover less than 5% of the coated area. Localized penetration of moisture into the building. | Longitudinal cracks about 1mm wide and extending over up to a third of the coated area. Part of the coating has peeled off and moisture has penetrated into the building. | A considerable portion of the coating has peeled off or been shed; moisture penetrates, accompanied by the growth of fungi over more than a third of the coated area. |

Ceramic coating of interior walls

| **100 VERY GOOD** | **80 GOOD** | **60 MARGINAL** | **40 RUN-DOWN** | **20 DANGEROUS** |
|---|---|---|---|---|
| The coating is whole; there is no abrasion of the ceramic surface and no | The coating is whole; there is no abrasion of the ceramic surface, but there is some | There is abrasion due to natural wear, but the defects are mainly esthetic, not | There are functional defects and damage in about a third of the coated area. | A considerable portion of the ceramic coating is defective and/or loose, also |

| | | | | |
|---|---|---|---|---|
| mechanical damage of the coating. | damage and breakage in a few places. | functional | | constituting a safety risk. |

Flooring

| 100 VERY GOOD | 80 GOOD | 60 MARGINAL | 40 RUN-DOWN | 20 DANGEROUS |
|---|---|---|---|---|
| The flooring is undamaged; there is no abrasion of the surface. No mechanical damage of the flooring. | The flooring is undamaged. There is no abrasion of the surface; but there are depressions (sunk tiles) in a few places. | There is abrasion due to natural wear, but the defects are mostly of an esthetic nature and not functional. | There are defects and functional damage in over a third of the surface area of the flooring. | A considerable part of the flooring is defective and loose, also constituting a safety risk. |

ELECTRICITY

The electricity system

| 100 VERY GOOD | 80 GOOD | 60 MARGINAL | 40 RUN-DOWN | 20 DANGEROUS |
|---|---|---|---|---|
| No need of increasing the power (replacement of wires, and control panels). All the electronic circuits and the fuses are adequate. | Some parts need to be replaced (wires and ducts), or extended (circuits). A minor addition of power is needed (replacement of fuses). | There is a need to extend a lot of the circuits, or to add some new. There is a need to replace the existing fuses. | There is a need to replace most of the circuits, and to add some new. There is a need to add new fuses in most of the circuits. | A considerable portion of the wires, ducts, and control panels have to be replaced. Grounding must be added. |

Electrical boards

| 100 VERY GOOD | 80 GOOD | 60 MARGINAL | 40 RUN-DOWN | 20 DANGEROUS |
|---|---|---|---|---|
| Electric boards are made of proper materials, new equipment, including gauging accessories. | The boards and the equipment are in good condition; however, there are some mismatches. There is a lack of some signposts | The structure of the boards is fair and safe. Wiring in a fair condition, fits the short and the loading currents. There is a lack of signposts. | The structure of the boards is poor, but it is still safe. The cables are dense. Screwed fuses or old equipment. There is no current switch. | The electric boards are not adequate and dangerous. There are flammable materials. The boards are loaded up to the limit. Dangerous accessories, and screwed fuses. |

Transformers

| 100<br>VERY GOOD | 80<br>GOOD | 60<br>MARGINAL | 40<br>RUN-DOWN | 20<br>DANGEROUS |
|---|---|---|---|---|
| Oil transformers sealed or dry. Connections are in good physical shape, separating networks exist, appropriate signposts. | Transformers in good condition. | Minor improvements are needed. | Old transformers, but in fair condition. Filters in a fair condition. Not many leaks. Acidic oil. | Old transformers, in poor condition. A lot of leaks. A lack of separating networks. Oil tests are marginal. Filters must be replaced. |

Pipes and ducts

| 100<br>VERY GOOD | 80<br>GOOD | 60<br>MARGINAL | 40<br>RUN-DOWN | 20<br>DANGEROUS |
|---|---|---|---|---|
| There is no need of improvement. | There are some places to repair. | There are some places to replace. Some duct paths have to be restricted. | There is a need to add or to replace about 20% of the wires and ducts in the building. | A considerable part of the wires and ducts must be replaced. |

Switching equipment

| 100<br>VERY GOOD | 80<br>GOOD | 60<br>MARGINAL | 40<br>RUN-DOWN | 20<br>DANGEROUS |
|---|---|---|---|---|
| Standard equipment, in perfect and safe condition. There are signposts where needed. Standard grounding-band. | Standard pass, in good condition. Standard grounding-band. | Equipment is in safe condition. | Upper-pass is open. Disconnections in poor condition. There is a lack of signposts. | Dangerous pass conditions. Accessories are broken. Disconnection equipment is not adequate for the service loads. There is a lack of protective infrastructure |

Conductors and cables

| 100<br>VERY GOOD | 80<br>GOOD | 60<br>MARGINAL | 40<br>RUN-DOWN | 20<br>DANGEROUS |
|---|---|---|---|---|
| There is no need of improvement | There are some places to repair. | There are some places to replace. | Cables are not suitable. About 20% of the cables | Mechanical damages in the cables. Cable sections too wide |

| | | | | |
|---|---|---|---|---|
| | | | in the building have to be replaced. | for the current. Cables are not suitable. |

Grounding protection

| **100 VERY GOOD** | **80 GOOD** | **60 MARGINAL** | **40 RUN-DOWN** | **20 DANGEROUS** |
|---|---|---|---|---|
| Wire-ways in perfect condition. There are signposts. Appropriate Grounding resistance. | Appropriate grounding resistance. Deterioration of connections due to ageing. | Appropriate grounding resistance. Connections in fair condition. Connection electrodes in fair condition. | Connections in poor condition or corrosion. Grounding conductors in poor condition | No grounding resistance. Decaying Grounding connections. Broken potential comparison band. Unstable and Crumbled connections. |

Electrical Accessories

| **100 VERY GOOD** | **80 GOOD** | **60 MARGINAL** | **40 RUN-DOWN** | **20 DANGEROUS** |
|---|---|---|---|---|
| There is no need of improvement. | There are some places to repair. | There is a need to add some signposts. Some accessories have to be replaced. | About 20% of the accessories have to be replaced. | Broken, faulty, rusted, or missing accessories. |

Lighting accessories

| **100 VERY GOOD** | **80 GOOD** | **60 MARGINAL** | **40 RUN-DOWN** | **20 DANGEROUS** |
|---|---|---|---|---|
| Perfect illumination. Accessories in perfect condition. There are signposts. | Good illumination. Accessories in good condition. | Fair illumination. Accessories in fair condition. Illumination uniformity is fair. | Low illumination level. Accessories in mechanical or electrical poor conditions. There is a waste of energy due to non-uniformity of illumination | Crumbled accessories. Broken or rusted covers. |

Peripheral lighting

| **100 VERY GOOD** | **80 GOOD** | **60 MARGINAL** | **40 RUN-DOWN** | **20 DANGEROUS** |
|---|---|---|---|---|
| Standard illumination level. | Effective illumination that fits the area. | There are some poles to repaint, and some covers | Low illumination level | Accessories are broken or rusted. Very low |

| | | | | |
|---|---|---|---|---|
| Durable accessories. | | to add. | (particularly from the buildings around). It is advisable to replace accessories or poles. | illumination level. There is a lack of accessories or poles. Dangerous poles position. |

SANITARY SYSTEMS

Water supply system

| **100 VERY GOOD** | **80 GOOD** | **60 MARGINAL** | **40 RUN-DOWN** | **20 DANGEROUS** |
|---|---|---|---|---|
| There is no visible damage to water pipes, its physical condition is good (no leakage or sealing), and it reaches to anywhere it is required in the building. | Water supply system is in general satisfactory condition, however, there are signs of initial failures (leakage, sealing). There are minor repairs required, as well as addition of end components. | Water supply system is in a condition that can meet the building requirements. Its physical condition does not necessitate a comprehensive rehabilitation, but only localized repairs, as well as addition of sanitary fixtures. | Most of water supply system should be rehabilitated. This includes addition of sanitary fixtures, replacement of pipelines, and many other repairs. | Water supply system does not work, since there are some disconnected sections. There is corrosion observed on pipes, and it does not reach many points in the building, where it is required. |

Sanitary accessories

| **100 VERY GOOD** | **80 GOOD** | **60 MARGINAL** | **40 RUN-DOWN** | **20 DANGEROUS** |
|---|---|---|---|---|
| The condition of the faucets, fixtures, and sanitary accessories is good, and there is no need of improvement. | Minor repairs are required in several places. | End components are missing in several places. | Approximately 20% of accessories should be replaced. | More than 20% of accessories are broken, damaged, or rusted. |

HVAC

| **Criteria for** | **100** | **80** | **60** | **40** | **20** |
|---|---|---|---|---|---|

| assessment | VERY GOOD | GOOD | MARGINAL | RUN-DOWN | DANGEROUS |
|---|---|---|---|---|---|
| * Completeness of insulation<br>* Completeness of piping<br>* General physical condition<br>* Connection points | | | | | |

FIRE PROTECTION

Fire detection

| 100<br>VERY GOOD | 80<br>GOOD | 60<br>MARGINAL | 40<br>RUN-DOWN | 20<br>DANGEROUS |
|---|---|---|---|---|
| 100% of floor area is protected by fire detection system, as required by Fire Protection Standards. | At least 75% of floor area is protected by fire detection system, as required by Fire Protection Standards. | At least 50% of floor area is protected by fire detection system, as required by Fire Protection Standards. | At least 25% of floor area is protected by fire detection system, as required by Fire Protection Standards. | Less than 25% of<br>floor area is protected by fire detection system, as required by Fire Protection Standards. |

Manual / automatic fire extinguishing fixtures

| 100<br>VERY GOOD | 80<br>GOOD | 60<br>MARGINAL | 40<br>RUN-DOWN | 20<br>DANGEROUS |
|---|---|---|---|---|
| 100% of floor area is protected by manual or automatic fire extinguisher system, as required by Fire Protection Standards. | At least 75% of floor area is protected by manual or automatic fire extinguisher system, as required by Fire Protection Standards. | At least 50% of floor area is protected by manual or automatic fire extinguisher system, as required by Fire Protection Standards. | At least 25% of floor area is protected by manual or automatic fire extinguisher system, as required by Fire Protection Standards. | Less than 25% of<br>floor area is protected by manual or automatic fire extinguisher system, as required by Fire Protection Standards. |

ELEVATORS
Machine room

| Criteria for assessment | 100<br>VERY GOOD | 80<br>GOOD | 60<br>MARGINAL | 40<br>RUN-DOWN | 20<br>DANGEROUS |
|---|---|---|---|---|---|
| * Oil leakage<br>* Shakings<br>* Acoustic noises<br>* General condition | | | | | |

Control panel

| Criteria for assessment | 100 VERY GOOD | 80 GOOD | 60 MARGINAL | 40 RUN-DOWN | 20 DANGEROUS |
|---|---|---|---|---|---|
| * Physical condition<br>* Wiring on panel<br>* Control accessories | | | | | |

Elevators doors

| Criteria for assessment | 100 VERY GOOD | 80 GOOD | 60 MARGINAL | 40 RUN-DOWN | 20 DANGEROUS |
|---|---|---|---|---|---|
| * Noises<br>* Closure of doors<br>* Mechanical / electrical reliability<br>* Aesthetics / paint | | | | | |

Suitability to handicapped

| Criteria for assessment | 100 VERY GOOD | 80 GOOD | 60 MARGINAL | 40 RUN-DOWN | 20 DANGEROUS |
|---|---|---|---|---|---|
| * Entrance door (80cm)<br>* Matching for blinds<br>* Floor display | | | | | |

Pneumatic delivery system

| Criteria for assessment | 100 VERY GOOD | 80 GOOD | 60 MARGINAL | 40 RUN-DOWN | 20 DANGEROUS |
|---|---|---|---|---|---|
| * Piping<br>* Accessories* Aesthetics / paint | | | | | |

COMMUNICATIONS AND LOW-VOLTAGE
Public announcement

| Criteria for assessment | 100 VERY GOOD | 80 GOOD | 60 MARGINAL | 40 RUN-DOWN | 20 DANGEROUS |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| * Control panel<br>* Accessories | | | | | |

Telephone system

| **Criteria for assessment** | **100 VERY GOOD** | **80 GOOD** | **60 MARGINAL** | **40 RUN-DOWN** | **20 DANGEROUS** |
|---|---|---|---|---|---|
| * Cables<br>* Accessories | | | | | |

MEDICAL GASES
Medical gases system (piping, boards, accessories)

| **Criteria for assessment** | **100 VERY GOOD** | **80 GOOD** | **60 MARGINAL** | **40 RUN-DOWN** | **20 DANGEROUS** |
|---|---|---|---|---|---|
| * Storage area<br>* Distribution center<br>* Piping<br>* Accessories<br>* Mobile gas systems | | | | | |

# Appendix C

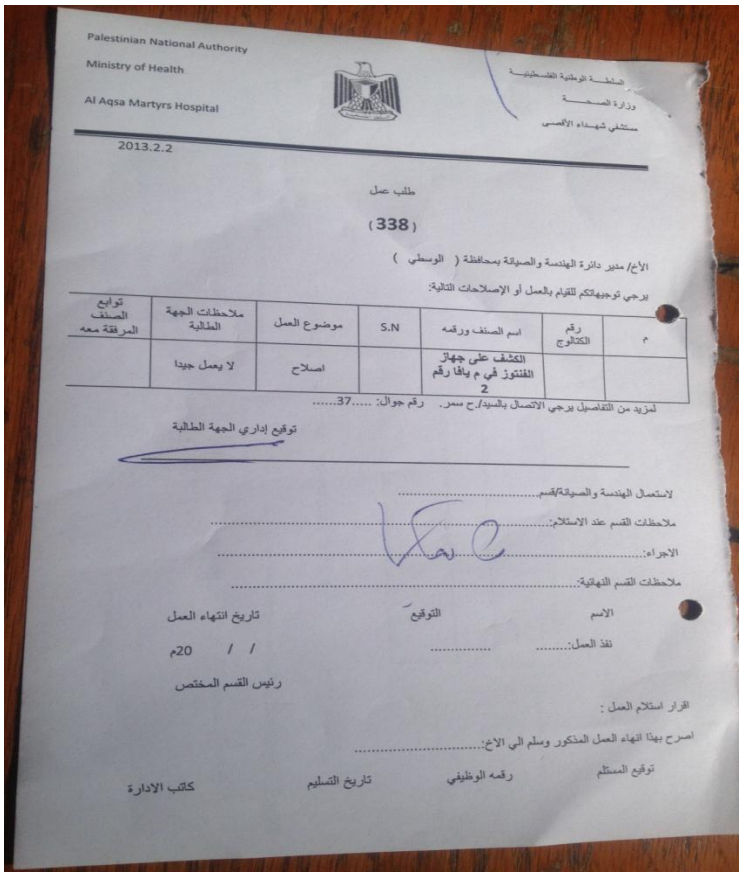
## Building coefficient in different environmental conditions "occupancy coefficient"

| Building's service life | In-land environment | | | Marine environment | | |
|---|---|---|---|---|---|---|
| | Low occ. | Stand. occ. | High occ. | Low occ. | Stand. occ. | High occ. |
| 1 | 0.3603 | 0.4235 | 0.4942 | 0.3805 | 0.4438 | 0.5145 |
| 2 | 0.3844 | 0.4127 | 0.4835 | 0.4047 | 0.4330 | 0.5038 |
| 3 | 0.3766 | 0.3988 | 0.5020 | 0.3968 | 0.4251 | 0.5222 |
| 4 | 0.3705 | 0.4205 | 0.5161 | 0.3908 | 0.4191 | 0.5364 |
| 5 | 0.3714 | 0.4423 | 0.5121 | 0.4010 | 0.4501 | 0.5417 |
| 6 | 0.3750 | 0.4482 | 0.5131 | 0.4130 | 0.4803 | 0.5510 |
| 7 | 0.4007 | 0.4235 | 0.5937 | 0.4386 | 0.4861 | 0.6316 |
| 8 | 0.4257 | 0.4540 | 0.6743 | 0.4637 | 0.4920 | 0.7122 |
| 9 | 0.4257 | 0.4540 | 0.6550 | 0.4637 | 0.4920 | 0.6930 |
| 10 | 0.4451 | 0.5289 | 0.6552 | 0.4742 | 0.5580 | 0.6843 |
| 11 | 0.4452 | 0.6038 | 0.6952 | 0.4655 | 0.6240 | 0.7154 |
| 12 | 0.4824 | 0.6046 | 0.7167 | 0.5027 | 0.6249 | 0.7370 |
| 13 | 0.5580 | 0.6055 | 0.6978 | 0.5783 | 0.6258 | 0.7181 |
| 14 | 0.5772 | 0.6055 | 0.6781 | 0.5975 | 0.6258 | 0.6983 |
| 15 | 0.8259 | 0.8550 | 1.0324 | 0.8505 | 0.8797 | 1.0570 |
| 16 | 1.0739 | 1.1045 | 1.3868 | 1.1029 | 1.1335 | 1.4158 |
| 17 | 1.0497 | 1.0987 | 1.3062 | 1.0787 | 1.1276 | 1.3352 |
| 18 | 1.0261 | 1.0928 | 1.2256 | 1.0550 | 1.1218 | 1.2546 |
| 19 | 1.0520 | 1.0995 | 1.3076 | 1.0810 | 1.1285 | 1.3366 |
| 20 | 1.1439 | 1.2032 | 1.4877 | 1.2055 | 1.2649 | 1.5493 |
| 21 | 1.2099 | 1.3003 | 1.5652 | 1.3042 | 1.3945 | 1.6595 |
| 22 | 1.1606 | 1.3064 | 1.5507 | 1.2549 | 1.4007 | 1.6450 |
| 23 | 1.1785 | 1.3126 | 1.5761 | 1.2728 | 1.4069 | 1.6704 |
| 24 | 1.2459 | 1.3126 | 1.5953 | 1.3401 | 1.4069 | 1.6896 |
| 25 | 1.0695 | 1.2037 | 1.3640 | 1.1569 | 1.2912 | 1.4515 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 26 | 0.8930 | 1.0949 | 1.1327 | 0.9736 | 1.1755 | 1.2133 |
| 27 | 0.8916 | 1.0949 | 1.1534 | 0.9722 | 1.1755 | 1.2340 |
| 28 | 0.9228 | 1.0949 | 1.1741 | 1.0035 | 1.1755 | 1.2547 |
| 29 | 0.9860 | 1.0891 | 1.0929 | 1.0666 | 1.1697 | 1.1736 |
| 30 | 1.0297 | 1.0800 | 1.1085 | 1.0665 | 1.1168 | 1.1453 |
| 31 | 1.0680 | 1.0827 | 1.2857 | 1.0610 | 1.0757 | 1.2787 |
| 32 | 1.0861 | 1.0815 | 1.3593 | 1.0791 | 1.0745 | 1.3522 |
| 33 | 0.9925 | 1.0744 | 1.3330 | 0.9855 | 1.0674 | 1.3260 |
| 34 | 0.9760 | 1.0744 | 1.3138 | 0.9690 | 1.0674 | 1.3068 |
| 35 | 1.2743 | 1.3506 | 1.5974 | 1.2596 | 1.3359 | 1.5827 |
| 36 | 1.5024 | 1.6267 | 1.8809 | 1.4801 | 1.6044 | 1.8586 |
| 37 | 1.5217 | 1.6267 | 1.8603 | 1.4993 | 1.6044 | 1.8379 |
| 38 | 1.5082 | 1.6267 | 1.8396 | 1.4858 | 1.6044 | 1.8172 |
| 39 | 1.5361 | 1.6258 | 1.8579 | 1.5137 | 1.6035 | 1.8356 |
| 40 | 1.5174 | 1.5311 | 1.7815 | 1.5369 | 1.5507 | 1.8010 |
| 41 | 1.4131 | 1.4315 | 1.6061 | 1.4745 | 1.4929 | 1.6675 |
| 42 | 1.3880 | 1.4256 | 1.5255 | 1.4494 | 1.4870 | 1.5869 |
| 43 | 1.4139 | 1.4323 | 1.6084 | 1.4753 | 1.4937 | 1.6698 |
| 44 | 1.3698 | 1.4390 | 1.6912 | 1.4312 | 1.5004 | 1.7526 |
| 45 | 1.1860 | 1.3955 | 1.5034 | 1.2507 | 1.4601 | 1.5681 |
| 46 | 1.1288 | 1.3528 | 1.3165 | 1.1967 | 1.4207 | 1.3844 |
| 47 | 1.1660 | 1.3537 | 1.3366 | 1.2339 | 1.4216 | 1.4045 |
| 48 | 1.1468 | 1.3537 | 1.3558 | 1.2147 | 1.4216 | 1.4237 |
| 49 | 1.0561 | 1.3608 | 1.3437 | 1.1240 | 1.4286 | 1.4116 |
| 50 | 0.9466 | 1.2929 | 1.2122 | 0.9926 | 1.3389 | 1.2582 |

## Appendix D

# Pictures



Palestinian National Authority
Ministry of Health
Al Aqsa Martyrs Hospital

السلطة الوطنية الفلسطينية
وزارة الصحة
مستشفى شهداء الأقصى

2013.2.2

طلب عمل

(338)

الاخ/ مدير دائرة الهندسة والصيانة بمحافظة ( الوسطى )

يرجى توجيهكم للقيام بالعمل أو الإصلاحات التالية:

| م | رقم الكتالوج | اسم الصنف ورقمه | S.N | موضوع العمل | ملاحظات الجهة الطالبة | توابع الصنف المرفقة معه |
|---|---|---|---|---|---|---|
| | | الكشف على جهاز الفنتوز في م بافا رقم 2 | | اصلاح | لا يعمل جيدا | |

لمزيد من التفاصيل يرجى الاتصال بالسيد/ ح سمر. رقم جوال: .....37.....

توقيع إداري الجهة الطالبة

لاستعمال الهندسة والصيانة/قسم.....

ملاحظات القسم عند الاستلام:.....

الاجراء:.....

ملاحظات القسم النهائية:.....

| الاسم | التوقيع | تاريخ انتهاء العمل |
|---|---|---|
| نفذ العمل:..... | ..... | / / 20م |

رئيس القسم المختص

اقرار استلام العمل :

اصرح بهذا انهاء العمل المذكور وسلم الي الاخ:.....

توقيع المستلم — رقمه الوظيفي — تاريخ التسليم — كاتب الادارة

Figure D.1 Maintenance request example

Palestinian National Authority
Ministry Of Health
Eng.& Maintenance Administrative

السلطة الوطنية الفلسطينية
وزارة الصحة
الإدارة العامة للهندسة والصيانة

التاريخ : 23 / 1 / 2013 م

شهادة انهاء صلاحية

رقم/.....16 / 2013.....

تقرر الإدارة العامة للهندسة والصيانة (دائرة المحافظة الوسطى ، قسم.....الرعاية الاولية.....) بانهاء صلاحية التالي:

| رقم الكتالوج | اسم الصنف (موديل) | S.N | العدد | رقم سند الادخال للقطع المستفاد منها |
|---|---|---|---|---|
| P2001540 | فرشة هواء | - | 1 | |
| | | | | |
| | | | | |
| | | | | |

الوارد للهندسة والصيانة من م.شهداء الاقصى / العناية المركزة

بطلب عمل رقم.....237.....

اسباب عدم الصلاحية : لا جدوى من اصلاحه

اسم المهندس المختص :.....م.احمد ابو سويرح.....

بتاريخ 23 / 1 / 2013 م

التوقيع :.....

أسماء اللجنة المختصة (خاص بإنتهاء صلاحية أنظمة بحاجة لقرار اللجنة)

التوقيع

.....1

.....2

.....3

ملاحظة مدير الدائرة: .....

اسم وتوقيع مدير دائرة الهندسة والصيانة بمحافظة الوسطى

.....م.مازن عطا العرايشي.....

- صورة للمخازن الرئيسية (المعهدة المستديمة)

يعتمد
مدير عام الإدارة العامة للهندسة والصيانة

Figure D.2 maintenance request example

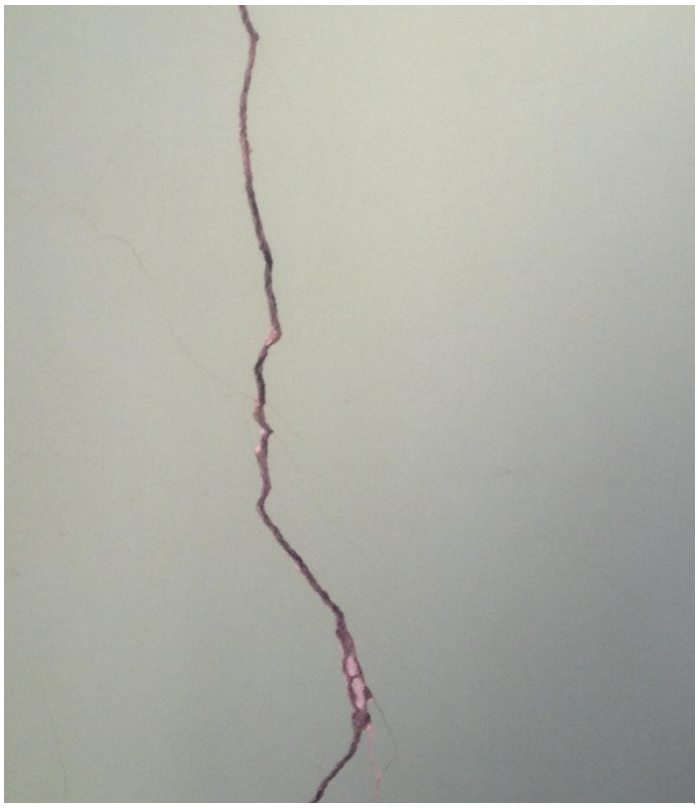
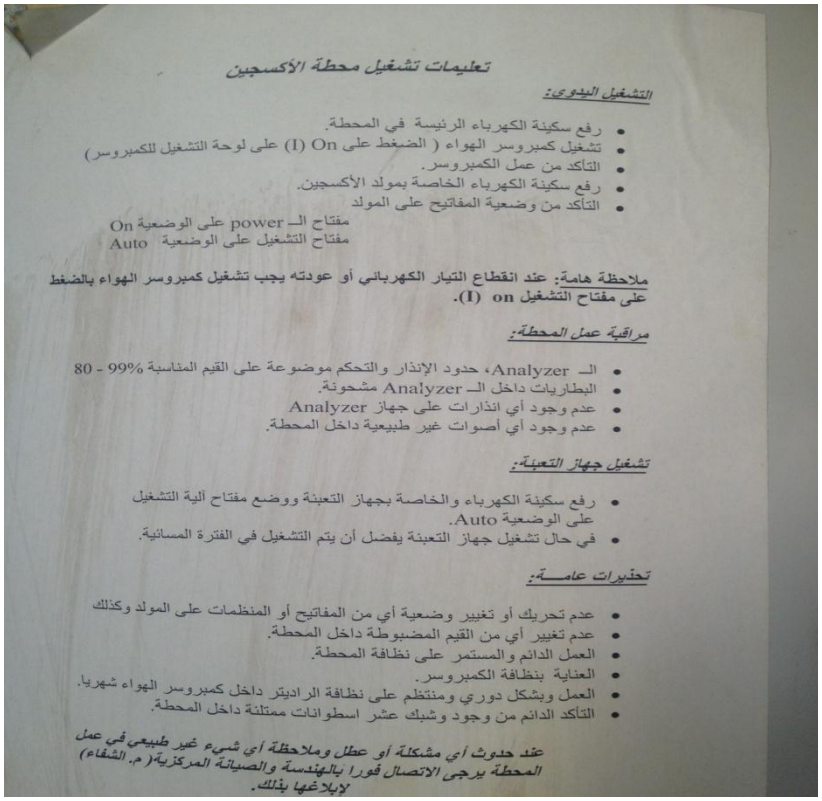


Figure D.3 Cracks in the interior walls

Figure D.4 Moisture in walls

Figure D.5 Moisture in walls


Figure D.6 Medical gasses station



تعليمات تشغيل محطة الأكسجين

التشغيل البدوي:

- رفع سكينة الكهرباء الرئيسة في المحطة.
- تشغيل كمبروسر الهواء ( الضغط على On (I) على لوحة التشغيل للكمبروسر)
- التأكد من عمل الكمبروسر.
- رفع سكينة الكهرباء الخاصة بمولد الأكسجين.
- التأكد من وضعية المفاتيح على المولد

مفتاح الـ power على الوضعية On
مفتاح التشغيل على الوضعية Auto

ملاحظة هامة: عند انقطاع التيار الكهربائي أو عودته يجب تشغيل كمبروسر الهواء بالضغط على مفتاح التشغيل on (I).

مراقبة عمل المحطة:

- الـ Analyzer، حدود الإنذار والتحكم موضوعة على القيم المناسبة 99% - 80
- البطاريات داخل الـ Analyzer مشحونة.
- عدم وجود أي انذارات على جهاز Analyzer
- عدم وجود أي أصوات غير طبيعية داخل المحطة.

تشغيل جهاز التعبئة:

- رفع سكينة الكهرباء والخاصة بجهاز التعبئة ووضع مفتاح آلية التشغيل على الوضعية Auto.
- في حال تشغيل جهاز التعبئة يفضل أن يتم التشغيل في الفترة المسائية.

تحذيرات عامـــة:

- عدم تحريك أو تغيير وضعية أي من المفاتيح أو المنظمات على المولد وكذلك
- عدم تغيير أي من القيم المضبوطة داخل المحطة.
- العمل الدائم و المستمر على نظافة المحطة.
- العناية بنظافة الكمبروسر.
- العمل وبشكل دوري ومنتظم على نظافة الراديتر داخل كمبروسر الهواء شهريا.
- التأكد الدائم من وجود وشبك عشر اسطوانات ممتلئة داخل المحطة.

عند حدوث أي مشكلة أو عطل وملاحظة اي شيء غير طبيعي في عمل المحطة يرجى الاتصال فورا بالهندسة والصيانة المركزية( م. الشفاء) لابلاغها بذلك.

Figure D.7 Medical gasses station

Figure D.8 Oxygen cylinders

Figure D.9 chillers

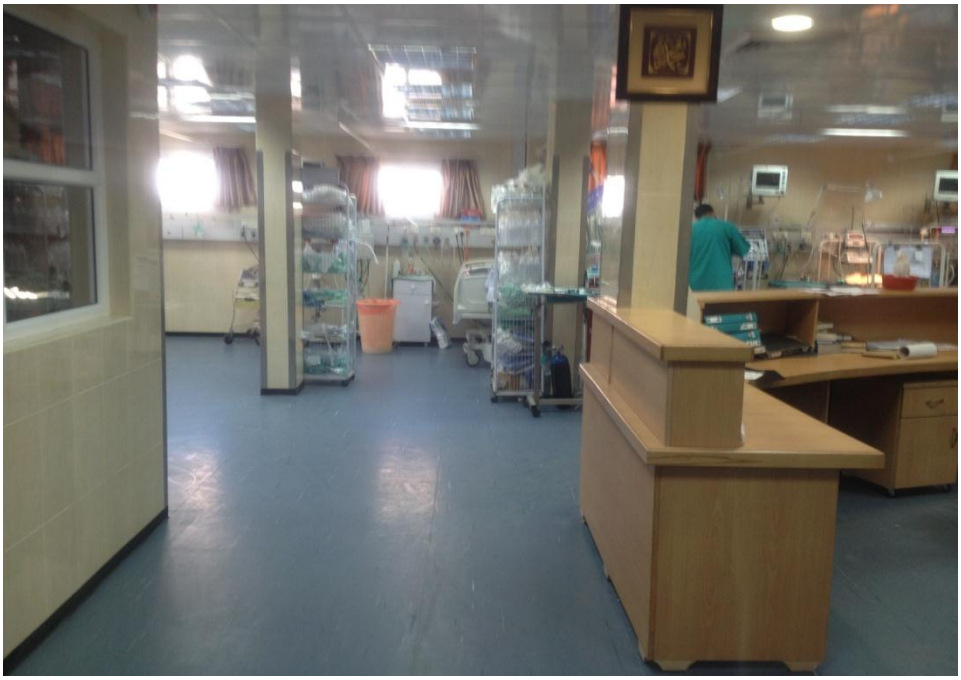


Figure D.10 Intensive care in Naser pediatrics hospital