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Towards a Smart GIS Public Health Record System for the Capital Governorate, State of Kuwait

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Abstract

Health care services are considered the sign of a contemporary civilized society, reflecting its level of modernity. A study of the developmental stages and location variables of health care services can facilitate understanding location characteristics for a progressive perspective to achieve optimal standards of health care service. This study focuses on the 17 public health centers located within the districts of the Capital Governorate, State of Kuwait. The scientific methodology that is used in this study is based on a spatial and geo-statistical analysis of public health centers. The results of this applied analysis highlight the inadequacies of the current management system running public health facilities in the State of Kuwait. The study seeks to create a new system based on GIS technology dubbed "Public Health Record Information System". The proposed system would not only rectify patient health record errors, but also improve the overall health management process.

Keywords: Public health care; Health record system; Smart GIS; Health geography; State of Kuwait

Introduction

Health care in the State of Kuwait never witnessed the existence of clear administrative systems prior to the twentieth century. Early health care was, therefore, limited to folkloric treatment derived from various local patterns performed by Mullas or Mutawas, largely comprising Quranic incantations, and to the use of procedures provided by barbers, as well as herbal remedies, and the Zaar.

At the turn of the twentieth century, the health care system was still a quarantine system--one of the oldest health administrative rules in the State of Kuwait. Quarantine was necessitated by the prevalence of uncommon and unknown plagues, as well as infectious diseases that continually decimated the population. For this reason, 1904 is distinguished as a major turning point in the history of health care services in the State of Kuwait, for in that year the first health clinic opened at Dickson's House, a small facility that treated patients, and performed surgeries. The clinic continued to develop and remain active until 1951, at which time the Health Quarantine Directorate, supervising the facility, evolved into the Department of Health.

Establishing a Department of Health in 1951 constituted a turning point in the history of health care in the State of Kuwait because it meant that control of health services was now relegated to the government. Prior to that, health service regulation in Kuwait was delimited to annual reports on the country's disease and plague control status, and to performing surgical operations. In 1952, at the administrative level, the Department of Health witnessed the election of a Higher Council of Health, comprising 12 members. Also notable is the Department of Health's employing Kuwaiti youth to work at both administrative and technical levels. However, it was British doctors and physicians from the Arab world who supervised the Department's medical level, which now included new divisions such as the Departments of Preventive Health; Health Awareness; Hospital Management; Clinics and Health Centers, and the Department of Social Health. In addition, the first Medical Pilgrimage Mission was formed in 1965. Another important role of the Department of Health was to issue a number of periodicals related to health awareness and orientation. The most important of these were the Health Journal (1951); Kuwait Today Journal (1954); Community Doctor Journal (1960), and the Journal of Family Doctor (1963) [1-5].

The administrative basis of the health field in the State of Kuwait was structured largely in the 1950s and '60s. Numerous

health laws and other legislation were enacted to organize the country's health care sector at the Department of Health's administrative and technical levels, as for example, in the area of birth & death registration. Then after a period of rapid growth between 1975 and 1985, the health care system underwent a stage of evaluation and revision. To implement future health plans and proliferate health awareness, the Ministry of Public Health sub-divided Kuwait into six health care regions: Farwania, Jahra, Adan, Mubarak Al Kabeer, Al-Amiri, and Shuwaikh--each responsible with providing services to approximately 300,000-500,000 people. The Ministry followed this divisional trend to create a non-centralized administrative system of modern health care. Moreover, it developed a health emergency system, and provided health care facilities with physicians and modern medical equipment. An official invested with full administrative authority was appointed to head each health care region.

Every region has a general hospital and other health units, including general and specialized clinics. In certain special cases, a patient may be referred to Sabah General Center, which comprises a number of specialized hospitals and centers including a Maternity Hospital; Psychiatric Hospital; Specialized Surgery; Orthopedic Hospital; Infectious Diseases Hospital; Physiotherapy Hospital; Rehabilitation; Chest Diseases, Tuberculosis Prevention; Cancer Center; Allergies Center; Nephrology Center; Dermatology Hospital Heredity Center; Ophthalmology Center; Dental Center; Chinese Needles Center (acupuncture), and Natural Herbs Center.

The State of Kuwait is made up of six governorates (Figure 1) consisting of approximately 70 districts constituting the narrow, inhabited coastal area along the Arabian Gulf. Dependent upon the design of ideal land area usage, each district contains basic infrastructure and services, including that of health care. Accordingly, health centers were established within all districts so that each area had a clinic offering services to families based on a system of health file records for each person living in that area [6].

Figure 1: Location map of the Capital Governorate, Kuwait. Source: Kuwait Municipality, Kuwait digital map, 2011.

Since health records include patient health history and address data, they are an important source of information easily impacted by human or other error. For example, the existence of duplicate files for a single individual, or an additional health record file in a clinic outside a patient's residential area both result in multiple, patient records. In additional, similarities in different individuals' full names constitute another problem due to errors in health follow-up caused by incorrect medical histories of presenting patients. The problematic associated with recording health information creates a major obstacle in the administrative and follow-up systems of any health department. Misdiagnosis or mistreatment of a patient based on another person's health history can potentially lead to serious iatrogenic conditions.

This study focuses on the 17 public health centers located within the districts of the Capital Governorate (Figure 1). The scientific methodology that is used in this study is based on a spatial and geo-statistical analysis of public health centers. The results of this applied analysis highlight the inadequacies of the current management system running public health facilities in the State of Kuwait. The study seeks to create a new system based on GIS technology dubbed "Health Management Information System". The proposed system would not only rectify patient health record errors, but also improve the overall health management process [7,8].

Description of the Research Problem

The importance of studying health care services comes with government efforts to realize programs that achieve social and economic goals. Although their importance has largely been limited to civilized societies in developed countries, health care services are gaining special attention in the policies of developing countries as growth and planning tools with which to uplift people and their societies.

The State of Kuwait was the first GCC country to found health care services with the establishment of the Health Department in 1936. The first government health clinic was also established, followed by the old Amiri Hospital (1949), along with specialized hospitals such as the Contagious Diseases, Psychiatry, and Chest Hospitals, all supervised by the Health Department affiliated with the Municipality.

After Independence in 1961, the Health Department was converted into the Ministry of Public Health, and the Maternity Hospital was opened, and a year later Al-Sabah Hospital (1962) opened its doors to the people of Kuwait. A system of health records was initiated while expanding the number of hospitals and health complexes. During the 1980s, five new hospitals were opened: Mubarak Al-Kabeer; Farwania; Jahra; Ibn Sina Specialized Hospital, and a renovated Amiri Hospital. This is in addition to specialized health facilities such as the Center for Islamic Medicine; Heredity Diseases Center; Kuwait Cancer Center; Razi Hospital for Osteology; Kuwait Center for Allergic Diseases, and Hamad Al-Issa Center for Organ Transplant.

The most important component of the health field's administrative phase was instituting a system of health areas in the State of Kuwait. A 3-tiered system (initial, secondary and tertiary health care levels) was designed and applied in the 1980's. However, the Iraqi invasion and its aftermath had a profound negative impact on the efforts and infrastructure of Kuwait's health care system. Wholesale destruction, plunder, and deportation all health care personnel caused the health care system to suffer enormous setbacks. Despite this, the State of Kuwait exerted tremendous effort to restore and restructure the health care service network in all its governorates.

Because health care services are an essential function of any society, many geographic researchers have contributed to studying problems associated with providing them. However, it is notable that health care services in the State of Kuwait have elicited little interest among geographic researchers--excluding Sultan's study (1998) which focused on the nature of health care in the State of Kuwait as compared to that of other countries. The study also touched upon regional distribution of these services in different areas of the country. Alzaher's (2004) study emphasized a characteristic analysis of health centers in the Jahra Governorate in the State of Kuwait [9].

The current study's methodology is to apply Geographical Information Systems (GIS) in analyzing the level of health care services offered in Kuwait. It focuses on the Capital Governorate as the object under consideration--since similar studies are scarce. The current study represents a serious attempt to uncover administrative errors in the existing system of health care services with respect to registration and follow-up. There are numerous instances of health file duplication, patient name mix-up and other issues hindering organized health care provision at any given location, based on actual population distribution [10].

Previous Studies

Health care service studies vary in type at the international level and can be classified as follows:

Studies tackling geographical distribution of health care service dependent on statistical techniques, the most important being-- Schneider (1967); Abernathy et al (1972); Hertzel (1978), and Philips (1990). These studies sought to improve development of health care services through better understanding: location planning; characteristics of beneficiaries, and factors affecting competent delivery of health care services.

Studies focusing on location distribution of health care services based on population growth rates; development of health care service centers' numbers, and workforce volume. The most important of these being Taylor's (1982), which emphasized the problem of public services distribution, especially in rural areas. The importance of location distribution studies is confirmed by Shannon & Dever (1974) who posited that quantitative and qualitative location distribution of health care resources is basic to providing effective health care [11].

An international study tackled the technology of Geographical Information Systems (GIS) in the field of health care services. Gesler (1986) emphasized using location analysis in medical geography to monitor the spread and location of diseases versus location of health care centers and hospitals. Lam (1986) determined location distribution patterns of cancer cases in China

using geographical information systems. Jacoby (1991) examined using modern techniques to detect geographical distribution of physiotherapy cases, and distances between people and health care centers. Sanson, Pfeiffer and Morris (1991) used GIS to pinpoint areas where animal disease spread. This study is diverse in methodology since it depends on the means of allo cating cases, gathering, storing and analyzing data to present findings in order to support environmental and civil planning. Kitron et al (1994) monitored Malaria cases in Palestine using GIS. Oranga's (1995) study depended on geographical information systems to locate population distribution around health care centers in certain African countries, especially those souths of the desert. Rushton et al (1997) used GIS in addressing concerns related to improving public health care services. Reissman et al (2001) used geographical information systems in the area of initial services to organize preventative pediatric health care follow-up. In addition, there are many studies, publications, and conferences periodically being held in the use of geographical information systems to improve health care services [12-15].

Developing countries have not been far behind with similar studies related to health care services. This is especially true in evaluating service status and drawing comparisons with developed countries, while identifying hindrances and providing solutions for upgrade. Some of the most important studies include Gestler's (1984) which emphasized the characteristics of developing countries' health care services; Annis's (1981) which focused on health care in Guatemala, and Siddiqi's (1980) which examined health service policies in relation to the development of Pakistan's health workforce.

As concerns the Arab region, there have been a number of geographical studies in the area of health care--especially in Egypt and the Kingdom of Saudi Arabia. The most important of these was Gomaa's (1978) regarding health care planning and development in Communist society. Also notable are Al-Zahrani's (1989) study dealing with health care services in Makkah, and Al-Kahtani's (1991) work on Saudi Arabian patterns of location distribution. Also noteworthy are Al-Ribdi's (1990) look at the geography of health care services in Saudi Arabia, and El-Bushra's (1980) study of the geographic distribution of Saudi Arabia services. El-Bushra also did a study (1985) on geographical population distribution and health care services in Yemen. A third study by the same author (1989) focused on Saudi Arabian patterns of geographical distribution and health care planning planning. Al-Walai's (1986) work focused on geographical distribution of diseases in Saudi Arabia, with special emphasis on location factors.

Geographical studies of Saudi Arabian health care have been extended to location modeling of services in the Baha area such as Al-Ghamdi et al's (1991) study. There were other studies analyzing regional distribution of services, which provided reasons for problems related to geographic distribution. These include studies conducted by Al-Kahtani (1994), and Al-Garallah (1997).

Locally, however, the efforts of geographic researchers in the State of Kuwait have been limited to just a few studies. These include the work of Sultan (1998), who presented a geographic and analytical study of Kuwaiti Kuwait health care services, and Al-Hamra and Al-Zaid's (1999) comparative study of patient referral satisfaction and level of service in initial health care centers. This is in addition to a number of specialized reports based on the most up-to-date study issued by Kuwait's Ministry of Health in 1999. Al-Jarallah (1996) focused on the development of health care services in the State of Kuwait since Kuwait's independence in the early sixties. Finally, Alzaher's (2004) work, the latest effort associated with the topic of this study, differs from it because its focus is on analyzing the characteristics of initial health care centers in the Jahra Governorate in the State of Kuwait [16].

Prior studies clearly indicate that there has been no serious Arab research to analyze health care service administration. Previous studies were lacking in the areas of hierarchy, supervision & guidance, and archiving of patient records—major factors in successful provision of health care. Therefore, the current study emphasizes these aspects while fully benefiting from GIS with respect to location and statistical analyses of administrative systems of health care service in Kuwait. The study uses the Capital Governorate in the State of Kuwait as an applicable model that can be generalized to other Kuwaiti governorates.

Objectives:

This study proposes to achieve the following objectives:

- Develop methodology to reduce medical record errors.
- Optimize health center allocation.
- Improve the system health care administrative.
- Create an automated control system for health services and management.

Methodology

- **Descriptive Approach:** covers the theoretical background for the development and administration of Kuwaiti health services and residential area based geographical distribution.
- **Statistical Analysis Approach:** covers medical services using Geospatial factors; quantitative population distribution among health areas; quantitative evaluation of service level, and client satisfaction.
- **Applied Technical Approach:** based on computer programming and simulation to propose computer-based models to optimize Geospatial metadata errors. It utilizes advanced Geo-information technology systems to structure accurate databases with reliable outputs needed by decision makers.

This study's above-mentioned research methodology will be implemented by:

1. Designing a residential database according to different residential areas vs. health centers.
2. Designing a digital map using GIS based on residential districts compliance with residential health center distribution, and geographical distribution of health centers per residential district.
3. Programming a Visual Basic simulation system to rectify geospatial metadata errors, especially in medical records.
4. Designing an applied model for specific areas of Health Services Management, using geo-databases to produce decision making user-friendly out-put.

Because Kuwait has approximately 74 districts within 6 different governorates, this large study framework would impact the sheer volume of the final analysis. Therefore, this study limits its focus to those districts in the capital governorate (Figure 2) representing 20 areas with 20 health centers, in addition to a number of clinics and specialized hospitals. It is recommended that the results of this study serve as a model for other governorates, in the State of Kuwait [17-20].

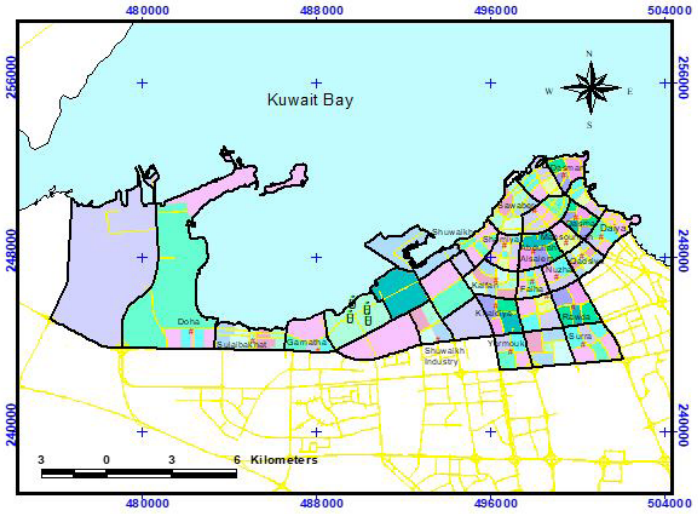

Figure 2: Study Area "Capital Governorate" and its Sub-Areas including the Public Health Centers. Source: Openware company, Kuwait, 2011.

In analyzing the questionnaire (Appendix A), it is evident that numerous administrative problems warrant attention, as follows:

1. Loss of health files, especially expatriate files in about 85% of all health care centers.
2. Similarity in names within 71.4% of all health files necessitates a computer system linking names with other personal data such as date of birth and civil identity number.
3. 47.6% shortage in medical record data because doctors have *insufficient* time to complete records of diagnoses and other pertinent information.
4. 47.6% data deficiency is primarily due to lack of basic information (i.e. civil identity number, family/tribe name, address, date-of-birth etc.), resulting from lax medical record employees failing to record complete data upon *first* opening health files for new patients.
5. Keeping active patient health records for patients who have moved to other residential areas creates major problems caused patient carelessness in transferring health files to the new clinic. This leads to two-or more--sets of active files at different clinics, a situation requiring a nationwide administrative system preventing such duplication.
6. Administrator absenteeism is remedied by holding administrators accountable for carrying out their duties by creating a system that organizes and supervises daily work hours.
7. The current study has depended on the latest statistical data published 1999, thus *indicating a lack of current data*. This reflects a statistical dysfunction in the health care system.

Analysis of the Percentage of Concentration in Health Care Services

In studying Figure 3, which shows the location distribution of quantitative health care services represented in the number of doctors, nurses, and administrative staff, the following characteristics from Figure 4 can be extracted as follows:

- There is an imbalance in location distribution in health care services factors represented in doctors, nurses, and administrative staff. This is due to the difference in the numbers of doctors, especially in Khaldiya, Faiha', De'eiya, and Doha health care centers. The number of doctors is three times that of doctors in Mansouriya, Shuwaikh, Shamiya, and Granada's health care centers. This is primarily due to the presence of additional specializations in the above-mentioned area centers. The Ophthalmology Center in Khaldiya serves all areas in the Capital Governorate, while Faiha's Dentistry Center extends its services to nearby areas. The remaining areas with disproportionately high numbers of doctors reflect administrative deficiencies in allocating medical personnel. This is especially the case when the areas that have a higher number of doctors do not have additional health care services such those in Faiha' or Khaldiya.
- There is an imbalance in distribution of nursing staff and assistants. The differences in distribution among health care centers is clear since there are equal numbers of doctors and nurses in health care centers such as Granada, Shamiya,

Dasman, and Sulaibikhat, but unequal numbers of doctors and nurses in other areas. This represents a shortage in health care services since the number of nurses is noticeably less than the number of doctors in Doha, Qadsiya, Yarmouk, Surra, Rawdha, and De'eiya health care centers, while there are more nurses than doctors in Abdulla Al-Salem, Murqab, Dasma, and Shuwaikh. This disparity confirms the lack of a proper administrative system that would ensure balanced distribution of assistant health care personnel [21].

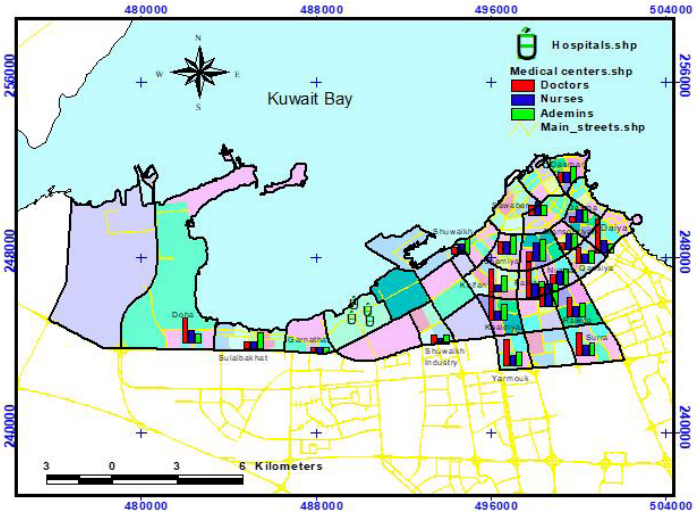

Figure 3: Distribution of Doctors, Nurses, and Administrators.

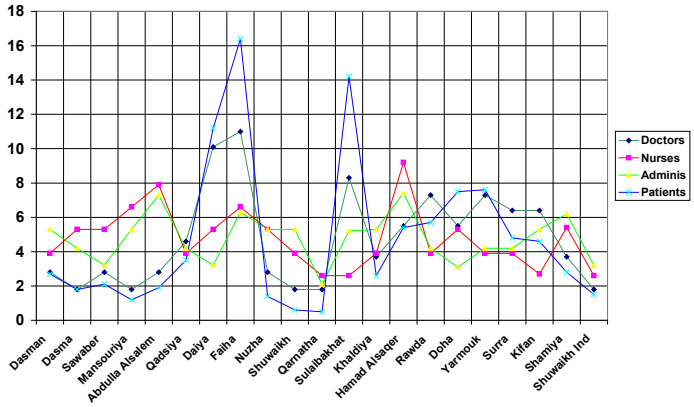

Figure 4: Centralization Rate of the Health Services. **Source:** Based on Table 1.

No.	Health Care Center	Doctors		Nurses		Admin. Staff		Referrals #	
		No.	%	No.	%	No.	%	No.	%
1.	Dasman	3	2.8	3	3.9	5	5.3	42466	2.7
2.	Dasmah	2	1.8	4	5.3	4	4.2	27838	1.8
3.	Sawaber	3	2.8	4	5.3	3	3.2	33030	2.1
4.	Mansouriya	2	1.8	5	6.6	5	5.3	18411	1.2
5.	Abdulla Al-Salem	3	2.8	6	7.9	7	7.4	30177	1.9
6.	Qadsiya	5	4.6	3	3.9	4	4.2	54224	3.5

7.	De'iya	11	10.1	4	5.3	3	3.2	173198	11.2
8.	Faiha'	12	11	5	6.6	6	6.3	253861	16.4
9.	Nuzha	3	2.8	4	5.3	5	5.3	21060	1.4
10.	Shuwaikh	2	1.8	3	3.9	5	5.3	9914	0.6
11.	Granada	2	1.8	2	2.6	2	2.1	8224	0.5
12.	Sulaibikhat	9	8.3	2	2.6	5	5.3	220595	14.2
13.	Khaldiya	4	3.7	3	3.9	5	5.3	40300	2.6
14.	Hamas Al-Saqer	6	5.5	7	9.2	7	7.4	84148	5.4
15.	Rawdha	8	7.3	3	3.9	4	4.2	87694	5.7
16.	Doha	6	5.5	4	5.3	3	3.2	116626	7.5
17.	Yarmouk	8	7.3	3	3.9	4	4.2	117278	7.6
18.	Surra	7	6.4	3	3.9	4	4.2	74789	4.8
19.	Kaifan	7	6.4	2	2.6	5	5.3	71585	4.6
20.	Shamiya	4	3.7	4	5.3	6	6.3	41748	2.7
21.	Industrial Shuwaikh	2	1.8	2	2.6	3	3.2	22566	1.5
		109	100	76	100	95	100	1549632	100
Source: The Questionnaire Data appendix (1), in addition to the calculation of percentages by the researcher.									

Table 1: The percentage of concentration of health care services, doctors, nurses, and administrative staff, along with the percentage of referring patients.

The implemented methodology for improving the Capital Governorate's health care administrative system is as follows:

1. Establish an administrative database.
2. Establish a health database for patients.
3. Establish a population database in areas affiliated to health care centers.
4. Establish a statistical database for severe medical cases.
5. Establish a location database (maps).
6. Design an information system to link the different databases.
7. Enter location analysis functions to the comprehensive information system.
8. Add a report preparation system for current, daily, monthly, and yearly reports-as needed.
9. Add an opinionative system asking for patients and population's views.
10. Add a performance evaluation system for administrative and medical performance.

The specifications of each sub-system of the above ten systems can be determined as well as their assigned tasks and linkage to other systems as follows (Figure 5):

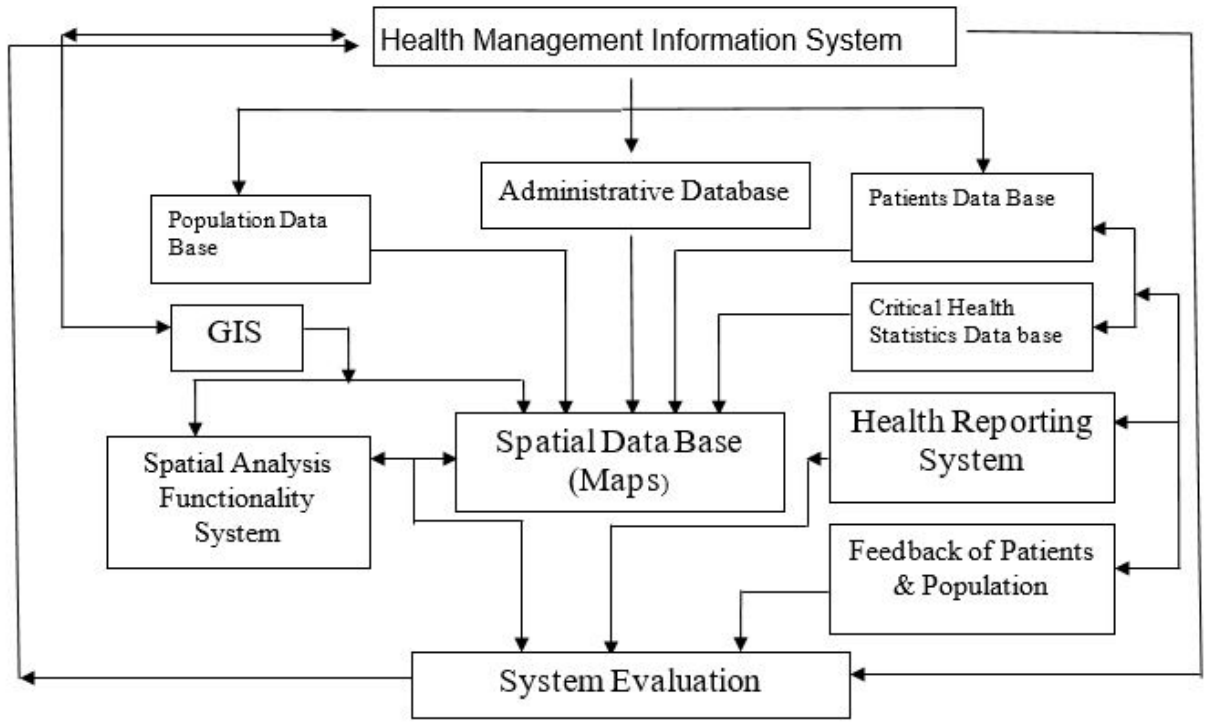

Figure 5: Structure of the components of the Public health record system.

Administrative Database

This consists of the administrative hierarchy, medical workforce, and doctors and nurses' personal data, position, work history, specialization, work hours, grants, penalties, violations, etc. [22].

Population Database

This includes detailed and demographic data about the population in residential areas affiliated to the health care center (i.e. name, gender, nationality, civil ID number, home address, telephone number, date of birth, place of birth, occupation).

Patients' Database

Consistent design of the health file contains the following data: name, civil ID number, date of birth, home address, telephone number, nationality, gender, occupation, health status, date of referral, treatment, and doctor's remarks.

Critical Health Statistical Database

Comprises critical health cases and includes: name, civil ID number, home address, telephone number, critical health cases, date of referral, follow-up date, treatment, and doctor's remarks.

Spatial Database

It includes a detailed map of the blocks in a residential area affiliated to a health care center, roadmap, and significant area landmarks (i.e. schools, government buildings, and private buildings). Also included is geo-coding address data pertaining to plot number, street, block, and area name, and name of governorate.

Health Management Information System

All databases and sub-systems--such as GIS, the daily work system, and performance evaluation system--are linked in the interface window on the user's monitor. Through this window, one language, either Arabic or English, can be chosen [23].

Spatial Analysis System

This consists of many analytical functions through links with population database, referrals information database, critical health cases database, and the map or the spatial database. The following analytical functions are performed:

- Spatial distribution of certain health cases.
- Allocating coverage area of health care center.
- Ability to rearrange coverage area by using the rezoning system.
- Searching for referral distribution in a certain time period.
- Other duties.

Health Reporting System

This can extract health or statistical reports based on health cases, age group, nationality, gender and time period (i.e. current, daily, weekly, monthly, and annual reports). This system contributes to overcoming statistical problems encountered by the current study, and represented in the old statistical published data. The latest published statistics go back to 1999, a five-year time period that would influence validity of research and queries dependent on these statistics.

Feedback of Patients and Population System

Placing computer monitors in waiting rooms (for men and women) would obtain patient feedback to help evaluate health administrative system performance.

Evaluation System

This system serves as a mirror that reflects health and administrative shortcomings derived from referral feedback, regular administrative and organizational remarks, and different reports about doctors, nurses and administrative personnel.

GIS Procedures

The requirements of establishing a GIS system for the study include:

- Software: The ARC/GIS software will be used--with extensions such as spatial analyst and geo-statistical analyst, where both accomplish the study's required analytical functions.
- Database: Dependent on the Access Database because it is the best database that deals with GIS programs. It will be used to design administrative, population, referral, and critical health case databases.
- Programming language – Visual Basic is used to design a usage window linking the different databases, and to design sub-systems, such as health reporting, referral, population feedback, and performance evaluation systems.
- A base map of the study area will contain: location data regarding blocks, ownership, addresses, number of families, and number of residential units. It also has a network of main and side roads, and area geographical characteristics (i.e. schools, health care centers, governmental and private buildings, parks, etc.).
- Population and statistical data including demographic data about a residential area population affiliated with a health care center, including addresses--to facilitate linking with the base map (i.e. Geo-coding Addresses).
- Selecting a computer network connected to a main server with high specifications, initially serving all network parties only. This will establish a central unit of health information systems affiliated with the Ministry of Health, serving all medical installations in the State of Kuwait. Monitors will be distributed to all health care center work stations (i.e. reception, doctors, pharmacy, dressing rooms, administration, and men's & women's waiting rooms). There must be a future plan to set a monitor for the high level administration in the Ministry of Health to supervise daily performance while printing current reports, as needed [24-26].

According to Figure 6, the phases of executing the GIS system can be explained as follows:

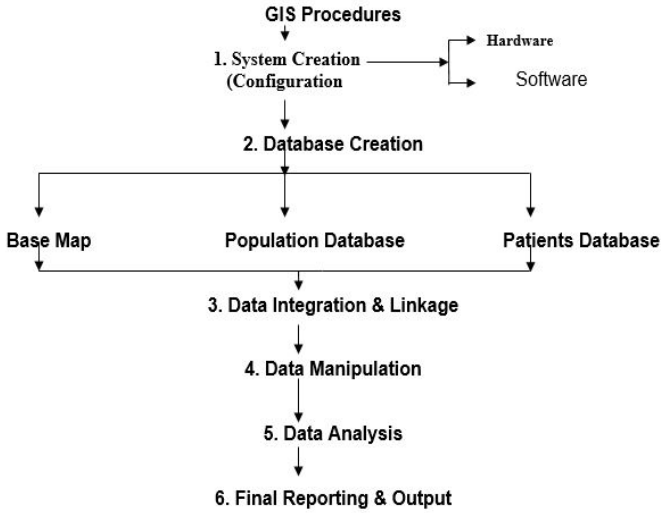

Figure 6: Implementation procedures GIS Health Management System for the Capital Governorate.

System Creation/Configuration Phase

This phase consists of selecting a hardware network including server, clients, and local network based on the Internet. It includes selection of specialized programs in GIS and aforementioned extensions.

Database Creation Phase

It includes three types of databases--the base map (the Kuwait Municipality map can be approved for the purpose), the population database (the data from the statistics sector in the Ministry of Planning or the Civil Identity System), and the referral information database, which converts patient health files from paper to digitally based files.

Data Integration and Linkage Phase

In this phase, integration among the three databases is completed:

Data Manipulation Phase:

This is an important phase since the data in the three databases needs many updating and error correction possesses

resulting from linking databases together.

Data Analysis Phase

A spatial and statistical analysis of information from above mentioned databases involves: isolating and identifying location distribution of certain health cases; distributing coverage range of health care centers, and re-planning coverage range through Rezoning System.

Final Reporting & Output Phase

Current, daily, weekly, monthly, and yearly reports are determined in this final phase, based on health system performance, population statistical data, medical cases, etc. This is a very important phase for decision makers to make the right decisions and avoid errors that have hindered development of health services (Figure 7).

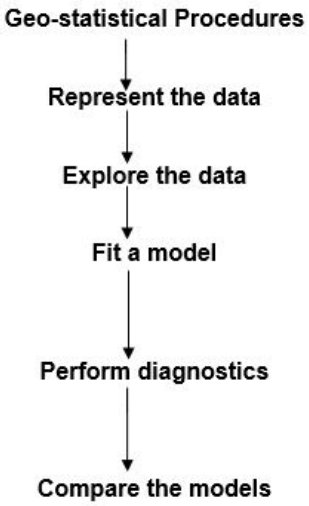

Figure 7: Implementation procedures of the Geo-statistical Analysis.

The stages of geo-statistical procedure can be described as follows:

1. Representing data; adding layers and display in the GIS.
2. Exploring data: investigate statistical and spatial of database properties.
3. Fitting a model: choosing a model to create a surface.
4. Performing diagnostics: assessing quality of output surface using cross-validation and validation tools to implement the model in order to predict values at unmeasured locations.
5. Comparing models: after creating multi-surfaces, cross-validation statistics can be compared [27,28].

Practical Implementation of the Proposed System

The practical implementation process takes several applied stages as follows:

Prefatory Stage

In this stage, a name is selected for the applied topic while determining the dimensions and specifications of the area being studied. Determining technical and data requirements to execute proposed implementation is done as follows:

1. Name of implementation topic: "Application of GIS and Spatial Statistics on the development of the Health Management System."
2. Study Area: select precise characteristics and specifications of the study area in a manner satisfying the spatial framework, consisting of a network of health care services. The applied area is the Capital Governorate in the State of Kuwait, comprising 28 residential areas, classified according to land usage, as follows:

- Investment and Residential Areas: Qibla, Murqab, Sharq, Dasman, and Bneid Al-Qar.
- Model Residential Areas: Dasma, Mansouriya, De'eiya, Qadsiya, Nuzha, Rawdha, Abdulla Al-Salem, Faiha, Shamiya, Shuwaikh, Kaifan, Khaldiya, Odailiya, Granada, Sulaibikhat, and Doha.
- Industrial Areas: Shuwaikh Industrial Area.
- Health Areas: Shuwaikh Health Area where the main hospitals and specialized centers are.
- Educational Areas: Shuwaikh Educational Area.
- Commercial Areas: Shuwaikh Commercial Area and Shuwaikh Port.
- Unused Areas: Doha Port Area.

The hierarchical plan of the areas in the State of Kuwait follows a pattern whereby the State is divided into 6 governorates, mainly: The Capital Governorate, Hawalli Governorate, Ahmadi Governorate, Mubarak Al-Kabeer Governorate, Farwaniya Governorate, and Jahra Governorate. A governorate is divided into a certain number of areas based on the governorate land-area. Each area is divided into a certain number of blocks--as is the case in other countries-- and the number of blocks varies, depending on the land-area of the area itself. The blocks are divided into parcels (plots), which are allocated for a single building with its annexes. In some cases, parcels are divided into smaller areas to be allocated for small residential buildings.

The study area "Capital Governorate" includes 21 health care centers distributed throughout the model residential areas, so that each residential area has a health care center. There are also health care centers in both industrial and commercial areas (Figure 2).

A. Data and Technical Requirements: Implementation necessitates technical requirements represented in a computer network, server and monitors, along with different programs.

Technical requirements of computers in the instance of current implementation are limited to one computer machine and a Printer. The required Software Programs to be used for implementation:

a. ARC/GIS

b. MS Access

c. Visual Basic++

d. SPSS

Data Requirements

- Residential data about the study area, which are residential statistics published by the Ministry of Public Health – the Health Record Supervision entitled "the Health Care Centers Registration Statistics in the State of Kuwait based on the health map" published in July 2001. It comprises a number of statistical tables with divisions based on population number, gender, and nationality in each block. A block is not the smallest residential unit since a unit can be divided into a number of plots. However, the residential data based on the plots is not permitted to be obtained. For the purpose of the current study, residential data was sufficient based on blocks in each residential area. The other advantage of available residential data is that it is divided based on the governorate--then the area, and suitably categorized according to its affiliation to a health care center in the coverage domain of health care services.
- Referral data for 1999 (based on health care centers') from the Ministry of Health's Central Department for Initial Health Care entitled "The Annual Report Appendix for Initial Health Care Services of Health Areas," should be the latest information, published to date. It consists of a number of tables that include categorization of referrals according to health care centers, nationality, gender, and age group.
- Data about health care centers was largely derived from the questionnaire (which contained a number of inquiries about the health care center: number of medical staff and medical specializations; coverage domain; inquiries about administrative problems (especially health files), and suggestions by the medical staff. This is in addition to a questionnaire about patients, which inquired about number of referrals, degree of satisfaction with the level of health care services, waiting time, and types of services offered. The questionnaire was tabulated using SPSS to interpret the current situation at the administrative level of health care services [29,30].
- Mapping data, which is the Base Map, accounted for the implementation. It was obtained from Openware Company, which is the local agent for the global company ESRI specialized in GIS. The map consists of the following mapping layers (Figure 3). The governorates' boundaries in the State of Kuwait including the study area--the Capital Governorate:

1. Area boundaries.
2. Blocks boundaries.
3. Main roads, side roads, and local roads network.
4. Attribute data for each of the above layers.
5. Geographic coordinates and national coordinates (KTM).

Data Entry Stage

The above data, obtained in the initial stages, is analyzed as follows:

1. Reading the base map in ARC/GIS Software.
2. Reviewing and making attached attribute data identical with the mapping layers.
3. Completing attribute data by entering population, and patient data, medical staff data (i.e., doctors, nurses, number of administrative subjects) and data about the number of medical specializations offered. This is done through adding more columns in the attribute data, to agree with type of mapping layer.
4. Entering questionnaire data (appendix 1) into SPSS program for analysis, while obtaining percentages of questionnaire topics (i.e. degree of satisfaction with the health care services and other). The most important of these is the problem with health files based on the study's questionnaire results.
5. Entering location of health care centers by developing a new mapping layer, in addition to completing attribute data of this layer with data associated with each center (i.e., number of people affiliated to the center; number of referrals, doctors, nurses, administrative subjects, and medical specializations or services on offer).

Data Tabulation Stage

In this stage many data analysis methods were carried out as follows:

1. Spatial Analysis: a data analysis to conclude the following:

A. Coverage domain of every health care center

B. Quantitative comparison between number of referring patients and population statistics in each health care center

C. Quantitative comparison of the numbers of medical staff : doctors, nurses, administrators

2. Statistical analysis on questionnaire findings using SPSS to reach the following results:

A. Percentage of health care centers experiencing administrative problems

B. Percentage of health care centers with health file problems

C. Types of common problems

D. Suggestions from medical staff

E. Suggestions from patients.

User Interface Programming

Visual Basic is approved as the language to be used to reach the following:

1. Initial user interface that includes the following:

A. Name of ministry (Ministry of Health).

B. Name of health department (Health Department in the Capital Governorate).

C. Ministry logo (Ministry of Health).

D. Two buttons to choose between Arabic and English.

E. Small window to enter the user name and password (Figure 8).

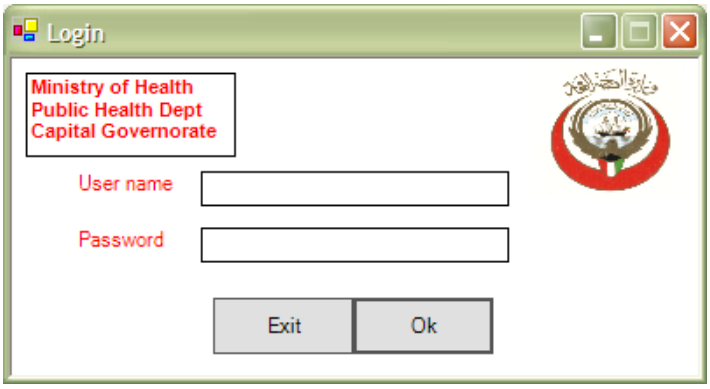

Figure 8: Log in Design: User Interface.

2. Second User Interface (Main Menu) (Figure 9) which includes the following data in the form of a button:

A. Administrative Database.

B. Patient Database.

C. Population Database.

D. Critical Health database.

E. GIS Base Map.

F. Health Reporting.

G. Work Schedule.

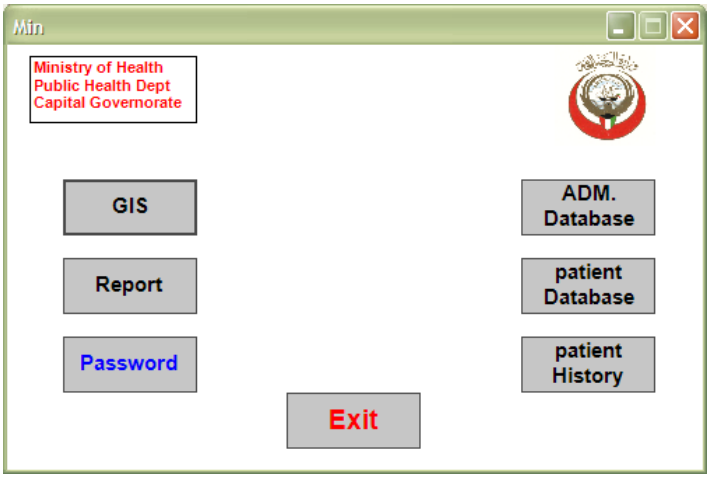

Figure 9: Design of the Main Menu.

3. GIS Interface (Figure 10):

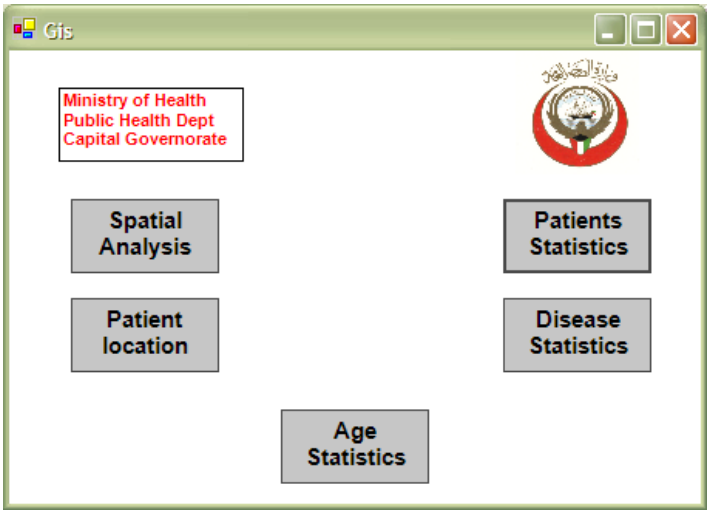

Figure 10: Design of the GIS Menu.

When the GIS button is chosen, the GIS user interface is opened. It is suitable for the regular user to access any of the following data:

A. Review of the Base Map.

B. Review areas within health care center coverage domain (Buffer Area).

C. Review areas with highest number of referring patients (Patients Area).

D. Review areas with a number of patients from . . . to . . . (Patients Statistics).

E. Review areas with certain types of diseases (Disease Statistics).

F. Review areas with a certain age group frequency (Age Statistics).

G. Others . . .

4. Administrative Menu Interface (Figure 11):

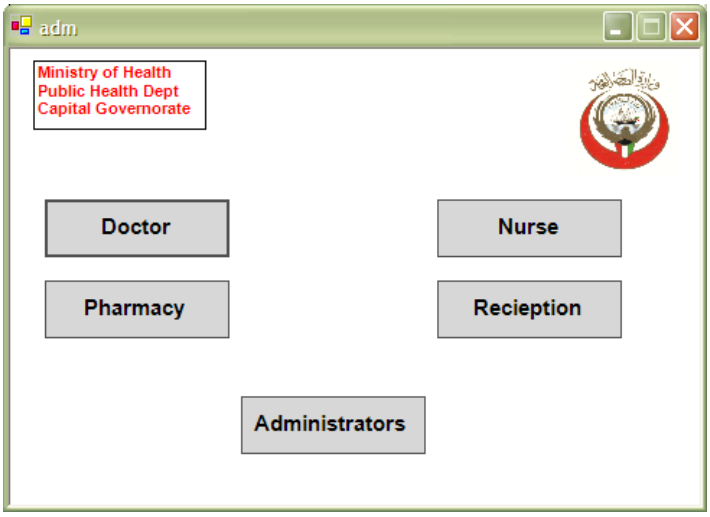

Figure 11: Design of the Administrative Menu.

This interface consists of the following attribute data:

a. Doctors – doctors assigned to the health care center.

b. Pharmacy – details about medicines.

c. Reception – health files storage.

d. Administrators – administrators assigned to the health care center.

e. Nurses – nurses assigned to the health care center [31].

5. Referring patients database interface (Figure 12):

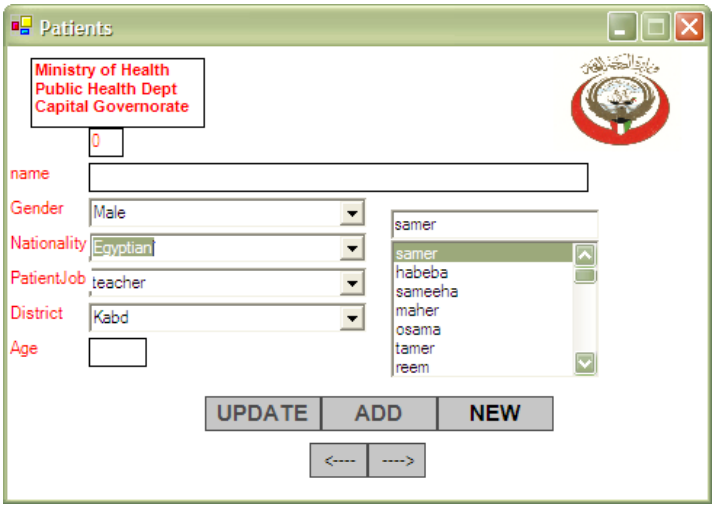

Figure 12: Design of the Patient Menu.

This interface menu consists of the following details:

a. Patient's civil ID number.

b. Patient's name.

c. Residential area (district).

d. Block number.

This interface is where reception starts to organize the waiting sequence of patients. Patients are handed waiting numbers and then distributed to different doctors based on individual case requirements [32,33].

When pressing the continue button of this interface, a patient's health file is opened in the form of a stable interface for all cases. Its contents are as follows (Figure 13):

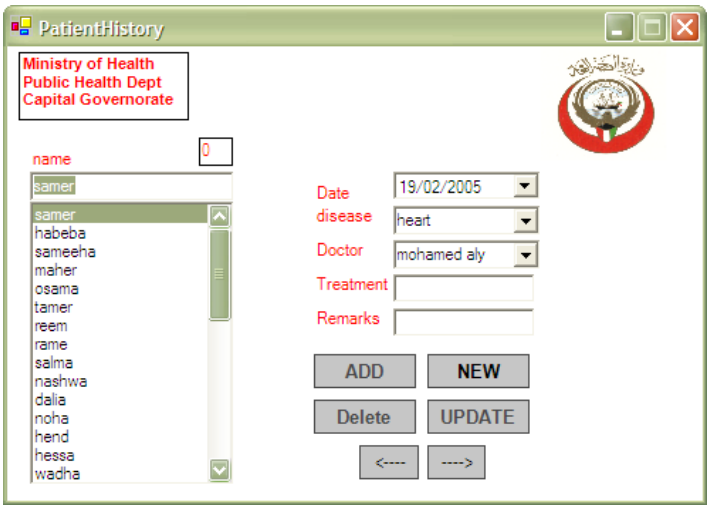

Figure 13: Design of the standard Patient File.

a. Patient's personal data: civil ID number, name, date of birth, nationality, gender, and address.

b. Date of last visit, case diagnosis, and type of treatment.

c. Health history of patient based on number of visits in terms of date, diagnosis, type of treatment, and doctors handling the case.

d. Date of current visit: . . . . . .

e. Diagnosis: . . . . . .

f. Treatment: . . . . . .

g. Doctor's remarks: the doctor can write remarks associated with critical cases or medical referrals to other health care centers or hospitals.

h. Storing data: above-mentioned data is stored in the patients' database, and then the file is closed.

6. Daily working schedule interface (Figure 14):

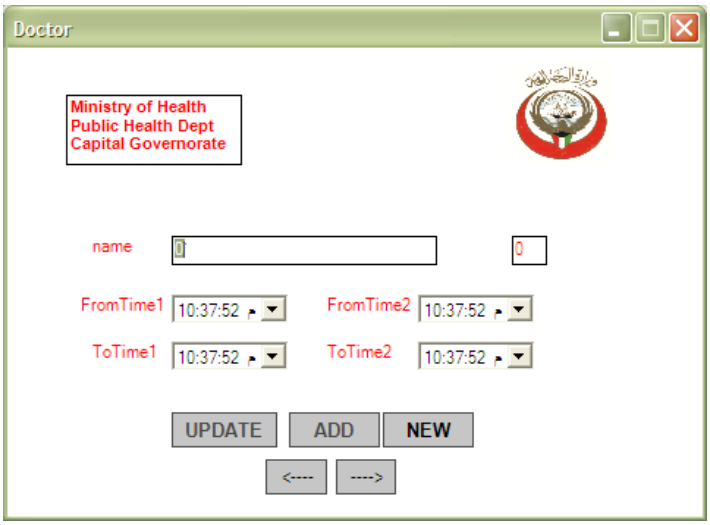

Figure 14: design of the Working Schedule Menu.

This interface enables inquiry into work schedules for medical and administrative staff, and contains following:

a. Doctors' schedule: posts doctors' names; working hours, and doctors on call.

b. Nurses' schedule: posts nurses' names; working hours, and nurses on call.

c. Administrators' schedule: posts names of administrators; working hours, and administrators on call.

d. Pharmacy schedule: posts names of pharmacists; working hours, and the pharmacists on call.

7. Medical report interface (Figure 15):

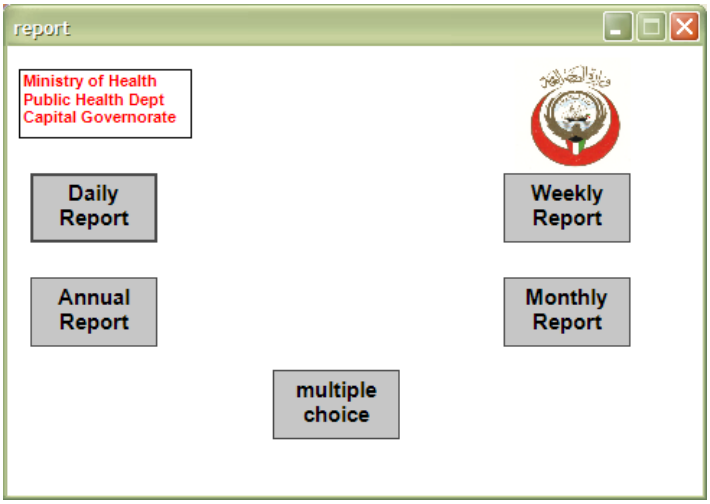

Figure 15: Design of the Reporting Menu.

This interface is extremely important since it wraps up the whole administrative system, health care services, performance evaluation, and other. The interface includes the following details:

a. Real Time Report: lists the case and the time of reporting.

b. Daily Report: consists of all completed duties in all departments.

c. Weekly Report: lists duties completed by all departments.

d. Monthly Report: lists duties completed by all departments.

e. Annual Report: lists duties completed by all departments.

Operating Stage

The operating stage is the final stage to implement the application of using modern technology, such as GIS and spatial statistics in developing health administration services and treating problems and errors through a completely updated system. The system will initially be applied in health care centers of the Capital Governorate. This is the practical result of the dissertation, after which it will be developed and implemented in other Kuwaiti governorates [34-37].

Conclusions

Public health services offered by study area centers constitute primary level urban health care universally available to all residential district inhabitants within the Capital Governorate. With virtually no discrimination in health care coverage, medical services are offered to all nationalities. The only exception to this is the fact that non-Kuwaitis pay a K.D. 3 (3.3 US$) surcharge per visit to reduce unnecessarily high numbers of patient referrals.

This purpose of this pilot study, on Capital Governorate health care centers, is to encourage further research by applying the same methodology to all Kuwaiti Governorates. Three methodological approaches were applied by this study:

1. **Descriptive Approach:** provided a background on the development of administrative and health services in the State of Kuwait, as well as geographic distribution of health care in residential areas.
2. **Applied Technical Approach:** utilized computer programming and computer simulation to propose computer-based models to optimize Geospatial metadata errors. Advanced Geo-information systems technology will enable decision makers to structure accurate databases with reliable output.

The study achieved the following objectives by using the above-mentioned methodology, as follows:

3. An introduction to the historical background of health care in Kuwait based on related literature and documents.
4. Evaluation and analysis of health care services based on a questionnaire.
5. Evaluation of existing health care administrative systems--while dealing with the different executive obstacles obstructing flexibility of the decision-making process, follow-up and control.
6. Evaluation of 'customer satisfaction' for the purpose of improving performance and delivery.
7. Development of an error reducing methodology for medical records.
8. Creation of a new Health Management Information System as an automated Control System for health management and services.

Insoluble problems arising throughout the study were as follows:

1. New statistical health service data: the latest, reported in 1998, still remains unpublished.
2. No information about the Health Ministry's future strategy for developing public health services.
3. Accessibility to health record files was complicated in some health centers.

The study makes the following recommendations:

1. Apply similar studies to other Kuwaiti Governorates, especially the proposed Health Management Information System (HMIS).
2. Create a core data base for the health services, and publish annually reports supporting research.
3. Extend the proposed Health Management Information System (HMIS) to include all health care types and hospitals.
4. Establish a Health Ministry GIS unit or center to update and maintain the proposed HMIS.
5. Conduct new studies concerning development of wireless communication to proposed HMIS for Ambulances on route to hospital. Instant access to patient historical medical saves on handling time for critical cases.

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